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ELECTRICITY IN MINES.

THE years of consideration and experiment bestowed upon the subject of accidents in mines by the Royal Commission appointed for that purpose have at length resulted in the publication of a report which, extending over 120 pages, will yet be read with close and critical interest by more than one class of persons. Though possibly the report will not in all points accord with the views of some who have long been eagerly watching for its issue, we have no hesitation in saying that it will be generally recognised as a valuable contribution to the current knowledge respecting the prevailing conditions beneath the surface of the earth. The interest with which electricians will examine it is due to the fact that a very general idea has arisen that the use of the electric light in mines would conduce greatly to the comfort and safety of the miner. This belief has led to the appearance of more than one form of electric lamp designed for miners' use, and doubtless others are undergoing the process of construction. The report of the Commission brings both hope and disappointment to the electrician, for while it speaks of the advantages in point of convenience and efficiency which attend the employment of electric glow lamps for illuminating the pit's bottom and roadways immediately adjacent, it also points out that, while the portable electric lamps upon which great hopes have been based, are perfectly safe, they do not afford any indication of the condition of the atmosphere in a mine, and that in consequence of this circumstance their employment, even where special fire-damp detectors are used, cannot entirely dispense with the necessity for the use of some other form of safety lamp. The meed of praise accorded to the electric light, however, is not stinted, and it is gratifying to have such eminent testimony to the fact that for exploring purposes after accidents, or in foul places, portable, self-contained electric lamps (such as have been described in the columns of the REVIEW within the last few months), must prove very valuable even in the present condition of their development; as auxiliary lights, the Commissioners add, they cannot fail to prove very useful. They recognise the great progress recently made in the construction of portable electric lamps, and perceive the promise of their speedy utilisation to an important extent in coal mines. With regard to the application of glow lamps to underground illumination through the medium of conducting cables leading from the generators to the pit bottom, it is laid down as essential to safety, as well as to the permanent efficiency of the installation, that the cables should be placed in positions where they would be thoroughly protected against possible accidental injury; and also that in all mines were fire-damp has been known to occur, the glow lamps should be excluded from direct contact with the air of the mine. Looking to the conclusions of the Commissioners, it seems that we must not be too ambitious with regard to mine lighting; and yet they give us very substantial encouragement to persevere in that direction.

Another portion of the Commissioners' report shows that the use of electricity is not exhausted underground when it is applied to illumination, for it states that electrical exploding appliances present very important advantages from the point of view of safety over any kind of fuse which has to be ignited by the application of flame to its exposed extremity, as the firing of shots by their means is not only accomplished out of contact with air, but is also under most complete control up to the moment of firing. Their simplicity and certainty of action have been much increased of late years, while their cost has been greatly reduced, and but little instruction is now needed to ensure their efficient employment by persons of average intelligence. For these reasons the use of electrical arrangements for firing shots in mines should be encouraged as much as possible.

HOW TO WIND MAGNETS FOR SHUNT, SERIES AND COMPOUND MACHINES.

By CARL HERING.

III.—SHUNT MACHINES.

To determine directly what the current and what the number of windings must be for the assumed thickness, c, of a coil, calculate the diameter of the naked wire from the formula, take the gauge number wire nearest to it, and measure its diameter with the insulation, which is best done by winding closely ten turns around a pencil or bolt, and measure the length of this little coil in inches; this multiplied by 100 gives the diameter of the covered wire in mils. Call this d_1. If the length of the core, or the space allowed for one magnet coil, be represented by e in inches, and the number of magnets on the machine by n, then it is evident that the number of turns per layer for one magnet will be

$$\frac{1{,}000\ e}{d_1}$$

while the number of layers will be

$$\frac{1{,}000\ c}{d_1}$$

and the number of turns per magnet $\frac{W}{n}$ will be their product,

$$\frac{W}{n} = 1{,}000{,}000\ \frac{e\ c}{d_1^2}$$

thus enabling one to calculate W directly, and consequently to determine a from (a W)

$$a = \frac{(a\ W)}{W}$$

If this current, a, is found to be very small, it might be more advantageous to use a greater current and less turns, and therefore less thickness, in that way decreasing the cost of the magnet wire, it being no small portion of the cost of the material of the machine.

If for a large machine the current turns out to be much smaller than 1·5 to 2·5 per cent. of the whole current, it shows that the machine has not the most economical proportions, and that the same frame may

be used, in case of incandescent light machines, with an armature having thicker wire and less turns, and therefore capable of supplying more lamps. Or in case of arc light machines, the same frame and armature may be used to give a higher potential at the same speed, thus supplying more lamps.

After finding what a is, it is advisable to calculate what current per square mil. this will give with the determined diameter, d, in order to guard against heating. In large magnets it should not be more than ·0013 ampères per square mil. If it is found to give a greater value than this it is safest either to take a smaller current and more turns, or to increase the diameter slightly. In many cases it will be found that the diameter obtained from the formula—in which it depends on the allowable resistance—will be larger than that which would be obtained if it were calculated not to heat too much ; but it is always safest to calculate both and take the largest.

If the current is found to be a large proportion of the total current, or if for the circulated diameter it is found that it will heat much, then the machine is overworked and ought to be used for doing less work, either by using the same armature and requiring the machine to give less electromotive force, or it may give the same electromotive force and less current, by taking a different armature with more turns of wire in it.

Owing to the fact that in most cases some insulating material, such as card-board or thick paper, is placed between some of the layers to ensure an evenness in the winding, the real thickness of the coil will be thicker than that assumed in the calculation, and, therefore, the mean length and resistance will be slightly different, but this error is covered by the factor of safety of 20 per cent. in the allowable resistance.

For the sake of appearances the last or outside layer is always wound full, thus limiting the number of windings to certain successive numbers which are multiples of the windings in one layer. In general, however, if the number of turns be increased a little, the resistance will thereby increase, and, therefore, the current decrease, but the product of the current into the number of turns will remain approximately the same.

If after the magnets are finally wound and the finished machine tested, it is found that owing to some slight error it gives a slightly lower or higher potential, the speed may be varied slightly to make up for this.

Having made all the calculations for the magnets of the finished machine, it is best to check them finally by calculating the resistance from the following formula :

$$\text{R} = 50{\cdot}13\ \frac{\text{W}\ l_m\ \theta}{d^2},$$

or if as before θ is taken 0·0162, and the temperature is assumed to be 70° F.

$$\text{R} = {\cdot}875\ \frac{\text{W}\ l_m}{d^2} = \frac{3{\cdot}5\ \text{W}\ l_m}{4\ d^2},$$

in which d is in mils, and l_m is the corrected mean length in inches, of a winding.

From Ohm's law

$$\text{R}_1 = \frac{\text{V}}{a},$$

in which R_1 is the total resistance of the shunt circuit, including the adjustable resistance. The amount which this adjustable resistance may be, is evidently

$$\text{R}_1 - \text{R}.$$

If this turns out to be a negative quantity, that is, if R is greater than R_1, there has evidently been a mistake made in some of the previous calculations.

If the calculated value of R is found to be too great, owing to the fact that the gauge number of wire taken was a little smaller than the value given by the formula, then it is quite safe to take the next size larger and keep about the same ampère windings, or else to modify the ampère windings accordingly, and then calculate R again as a check. It is quite safe to take a slightly larger diameter of wire for the same number of windings without any fear of increasing the resistance, for, from the formula of R, it will be seen that it increases only slightly, with an increased value for l_m, but decreases much more rapidly for a larger value of d.

If it is desired to regulate the machine for supplying the same potential to less lamps, by adjusting the resistance included in the shunt circuit, it is evident that it is only necessary to increase this resistance the proper amount, which can be done after the machine is finished, as it will change nothing in the preceding calculations.

If the machine is for arc lights in series, and it is desired to regulate it to supply less lamps, it will be necessary to make the test for both the maximum and minimum number of lamps and then make the resistance of the wire so low that in either case it is not too high to take its proper current, as required by its ampère windings for that particular potential.

The total length of the wire, in feet, for all the magnets will be

$$\text{L} = \frac{\text{W}\ l_m}{12} = {\cdot}0833\ \text{W}\ l_m$$

To illustrate the calculation of shunt magnets by the above-described method, let us assume that a certain machine with a given cylindrical armature and a frame with four cast-iron oval magnets, was required to supply 100 lamps of ·7 ampères each, that is, 70 ampères, of 100 volts. The speed is to be 1,200 revolutions.

Upon running the machine with four temporary magnet coils of 250 turns each, it was found to require an exciting current of 40 ampères to make the armature deliver 70 + 2·5 per cent. of 70 = about 72 ampères at 100 volts. This gives 250 × 4 × 40 = 40,000 (a W), as a measure of the magnetism.

The dimensions of the oval cross section were 9 inches by 3 inches. In order to determine the mean length of a winding, assume temporarily a maximum thickness of coil, one-third of 3, or 1 inch. The periphery of the core was measured and found to be 20 inches. This gives a mean length of one winding :

$$l_m = l + \frac{2\ c\ l}{a + b} = 23{\cdot}3 \text{ inches};$$

therefore from the formula

$$d = \sqrt{{\cdot}875\ \frac{(a\ \text{W})\ l_m}{\text{V}}}$$

assuming a factor of safety of 20 per cent. that is taking V equal to 80 volts instead of 100, the value of d is

$$d = 102 \text{ mils},$$

which is approximately equal to No. 10 wire.

Suppose this has an outside diameter of 125 mils. From the formula given above, the length of the core being 10 inches, there will be 80 windings per layer on each magnet, and 8 layers and therefore, 640 × 4 = 2,560 windings in all. This gives $\frac{40000}{2560} = 15{\cdot}6$ ampères in the windings. This very large current, which is 22 per cent., of the current in the external circuit, shows that the machine is very much overrated, and that it would not be economical, and even hardly possible, to finish the machine for 100 lamps. The heating would also be too much, for 15·6 ampères in a No. 10 wire is ·0019 ampères per square mil, which is too great. Furthermore, the core is more than saturated, for its area of cross section is about 21 square inches, which gives for 10,000 (a W) per magnet, 475 (a W) per square inch, which as compared with the constant 240 is far too great. Suppose the curve of magnetisation was found by the test to be $a\ d$ in Fig. 1. [*See* p. 228, March 12th.] It will be seen from it, that at 40,000 a W the magnets are very much oversaturated. This curve would have been sufficient in practice, without the above calculation to show that the machine was overrated, but for the sake of illustration here, the calculations were also made.

From these figures, and from what was said above, it will be seen that the magnets would have to be altered in order to use the machine with this armature. As they are over saturated, they will have to be given a larger cross-section. For a proper percentage of current for the magnets, the large number of windings would make the thickness c of the coil much larger than it ought to be, from which it follows that the new magnets must also be made longer. In other words, these magnets have shown themselves to be much too small for that armature, or the armature has too few windings for the magnets.

The same machine was then run with another armature, which had more turns of thinner wire, the size of the wire being such as to stand a current for 70 lamps. Another armature might have been made with the same thickness of wire, but with more layers, thus supplying about the same number of lamps; but this increases the per centage of loss of energy in the armature, it increases the lead of the brushes, increases the self induction and the sparking, &c., and is, therefore, not advisable.

Suppose the test with the new armature gave 18,000 (a W). Then the following values would be obtained directly from the formulæ:

$$d = 67{\cdot}8 \text{ mils.} = \text{about No. 14.}$$
$$(d_1 = \text{about } 88 \text{ mils.})$$
$$\text{W} = 110 \times 11 \times 4 = 4{,}840$$
$$a = 3{\cdot}7 \text{ ampères.}$$

The density of current in the wire should be ·00115 ampères per square mil., and therefore, as compared with our constant ·0013, it is safe against heating too much. The density of magnetism in the cores would be 214 ampère windings per square inch, and therefore, inside of the limit. The curve of magnetism, which will naturally be the same as before (except that it has a different scale for the abscissæ or volts, which does not affect the saturation), shows that for 18,000 (a W) the magnets are not quite saturated.

The resistance will be

$$\text{R} = {\cdot}875 \frac{\text{W } l_m}{d^2} = 24 \text{ ohms,}$$

giving an adjustable resistance of

$$\frac{\text{V}}{a} - \text{R} = 27 - 24 = 3 \text{ ohms.}$$

The reason why this is so small is because the resistance of the coil is greater, being 24 ohms, which is due to the fact that we selected the smaller size wire, No. 14, which is 64·08 mils. diameter, as that is the nearest to the calculated value of d, 67·8. If we take the next size larger to 67·8 mils., that is, No. 13, the resistance would be much less, but at the same time the current, a, would be greater, as there would then be less turns for the same allowable thickness of coil.

If this adjustable resistance of 3 ohms is thought to be too small to admit of the proper regulation or adjustment, the speed may be increased a little, or the next size larger wire, No. 13, might be taken.

As the density of magnetism in the core is shown to be 214 (a W) per square inch, it will be seen that in a second machine of the same type the cross-section of the magnet cores may be decreased, thereby diminishing l_m, which decreases d; which in turn increases R and decreases a; thus diminishing the cost of the wire and the cost of the energy to supply the magnets.

The cross section of the magnets may be decreased to such an extent as to bring the density of magnetism up to the saturation point, as given by the curve.

The constant 214 also shows that the same machine may be run at a less speed, or it may be used to give a higher potential, or the same frame may be used with an armature having a few turns less and slightly thicker wire, thus supplying more lamps.

As the density of the current in the wire is below ·0013, the first cost of the machine may be diminished at the expense of the efficiency, by taking more current in the magnets and less windings, and therefore less wire.

By a similar course of reasoning, it will often be found, from the results of such a test and the deductions made from it, that certain improvements can be advantageously made in the machine.

NEW TELEPHONE TRANSMITTERS AND RECEIVERS.

OUR second illustration shows a vertical section of a transmitter patented by Messrs. Edison and Sigmund Bergmann, which consists of two parts between which the diaphragm is held. The latter is clamped with packing rings, by which it is insulated from the case and by which a closed chamber is formed at the back of the diaphragm. The chamber is filled with liquid through the tube shown, which is closed so as to seal the instrument, preventing escape or evaporation. While a liquid is employed in this transmitter, it must not be inferred that it comes into the category of what are known as "liquid transmitters," as the liquid here only plays a mechanical part in the construction. In the new transmitter the liquid limits the movements of the diaphragm, which in turn limits and controls the separation of the electrodes. The liquid body, by preventing an excessive movement of the diaphragm, prevents the electrodes from moving too far, so that they quickly return to their normal position, and all the sound vibrations are responded to from the normal position of the electrodes. The liquid is preferably of oil, but may be of any other nature—mercury, for instance. The contact points are located outside of the liquid, as represented. A platinum contact point is carried by the front of the diaphragm, and against it bears another contact point, of platinum, carried by a screw. This screw is supported rigidly in the bridge within the front of the case, and is adjusted by a spindle. To close up the telephone and prevent the saliva from reaching the contact points, a second diaphragm is employed, held in its place by the mouth piece.

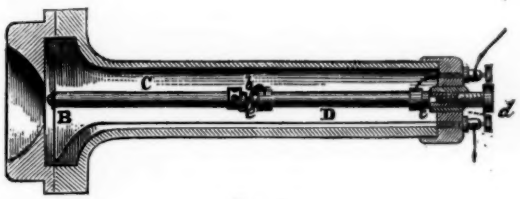


FIG. 1.

The telephone receiver is the device of Mr. Bergmann, of New York, and consists in the employment of one or more magnets acting upon a diaphragm so arranged and connected that the current passes axially through them, an adjusting device being provided to vary or regulate the extent of the space through which the force is exerted. Mr. Bergmann has found that when this is done the vibrations of the diaphragm correspond with the variations in the axial current, and sound is produced in accordance with the vibrations at the transmittter, the action being due to variations in magnetic intensity.

The best results have been obtained by arranging two or more magnets in line, with their ends in close proximity, such ends being connected by suitable conductors of the current. The magnets are connected in circuit, the current passing through them from end to end, or from centre to ends, or ends to centre in both directions.

Fig. 1 shows the receiver, which has been designed with special regard to simplicity of construction and to permanence of adjustment.

As will be seen, C, D, are two magnetised steel bars. These bars are arranged in line, with their adjoining ends in close proximity, leaving a space, b, for mecha-

nical movement between them. One bar is attached to the diaphragm and the other is supported by a sleeve, *c*, which is adjusted from the end of the case by a screw, *d*, so as to increase or decrease the attractive space, *b*. The adjoining ends of the magnet bars, C, D, are connected by a conductor, *e*, suitably arranged to permit free movement longitudinally of the bars. The terminals (or circuit connections) are connected one with the outer end of bar, D, through the adjusting sleeve, *c*, and the other with the outer end of

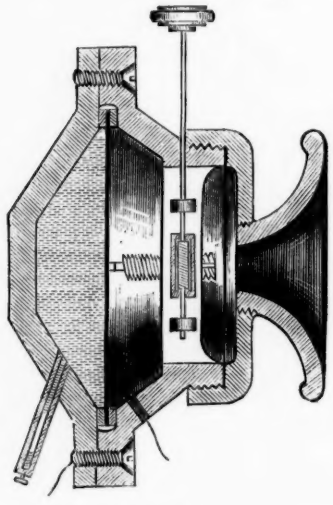


FIG. 2.

bar, C, through the diaphragm. The current of the circuit flows from a terminal through magnet bar, D, conductor, *e*, magnet bar, C, and diaphragm to the other terminal, or in the reverse direction. The effect is to vibrate the diaphragm and translate the telephone current vibrations into articulate speech. The effect is modified by adjusting the screw, *d*, and varying space, *b*.

It has been found that where two or more magnets are used the best effect is obtained if the opposite poles of the magnets are brought together, although the instrument operates when the same polarities are in proximity. Among the various modifications of the instrument is one in which electro-magnets are employed.

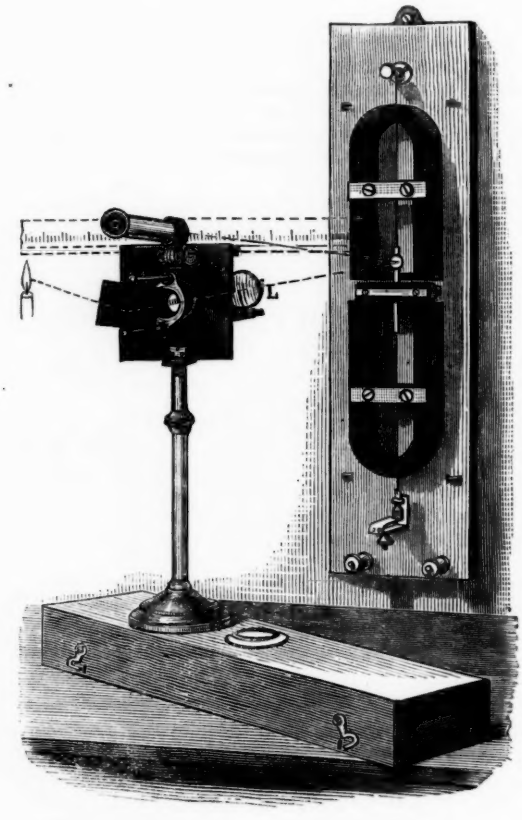
IMPROVEMENTS IN GALVANOMETERS.

M. E. DIEUDONNE describes, in *La Lumière Electrique*, certain improvements in galvanometers devised by Dr. d'Arsonval. The primary object of the inventor is the study of animal heat, but the modifications which he has introduced are likely to be of general utility. He has invented a micrometric scale which renders it possible to increase the sensitiveness of a mirror-galvanometer to any extent. He has recourse to an optical method, which bears entirely upon the process of reading off without increasing the inertia of the apparatus.

The process of Poggendorff generally employed consists in fixing a plane mirror to the movable portion of the galvanometer, and examining the image of the graduated scale through a telescope. He obtains thus an image smaller than the scale which is then magnified by the eye-piece of the telescope.

The sensitiveness is not proportional to the distance, since the image becomes smaller and smaller the further it is removed.

Dr. d'Arsonval, whose arrangement is shown in the accompanying figure, uses a scale in twentieths of a millimetre, photographed on glass, and illuminated by means of a lens or a mirror. A lens gives a magnified image, which after reflection in a second mirror is still further magnified by means of a second mirror furnished with a wire grating. The inventor substitutes for the plane mirror, not easily obtained, a concave mirror silvered on its posterior surface. He takes a plano-convex lens, silvered on its hinder surface, which thus forms a concave mirror giving a perfect image which can bear magnifying to 100 diameters; the sensitiveness of the apparatus is increased in the proportion of the magnifying power. Hence it is possible to read the slightest deviations with great precision, which renders the galvanometer both proportional and ready to use.



By a very simple arrangement this apparatus is transformed into a Carpentier's transparent scale. To this end a wire extended vertically is substituted for the micrometric scale, and for the eye-piece a graduated scale of celluloid, as is represented in the figure. The lens, L, placed in front of the micrometric scale answers a double purpose; it increases the clearness of the image, and, as it is movable, we may by simply sliding it, alter the magnifying power of the apparatus.

The arrangement being placed at 1·20 metre from the galvanometer, we can distinguish a displacement of the image equal to $\frac{1}{40}$ millimetre, or an angular deviation of $\frac{1}{4000}$ of a degree of a circle.

THE HUMAN BODY AS A CONDUCTOR AND AS AN ELECTROLYTE.

DR. W. H. STONE delivered the first of three Lumleian lectures on this subject at the Royal College of Physicians on Thursday, the 8th inst. He commenced by thanking the president and fellows of the venerable society in whose library they were assembled, for the permission they had granted him to issue more than the usual number of invitations to scientific friends who were not immediately connected with the medical profession, but

many of whom had materially helped him in his investigations, which had now lasted for five years. Amongst those to whom he was especially indebted and whom he wished sincerely to thank were Mr. Gregory, Dr. Oliver Lodge, Mr. Lant Carpenter, and, not least, Prof. Hughes. He then proceeded:

Let me begin by saying what these lectures are not going to be: they are not going to be lectures on what is called medical electricity, which is a term of ill-omen and is, indeed, incorrect. Hitherto the application of electricity to the human body has certainly not come up to expectations: it is evidently in embryo, in a state of origin, and it has come into use in medicine in a somewhat oblique and accidental manner. It is a good physiological stimulant, a good test of muscular irritability, and in this way it has been taken up more in a physiological than in a physical light. Besides this it has suffered grievously from misrepresentation. We see every day in the papers that "Electricity is life!" Now this is most undoubtedly untrue. No doubt some day we shall be able to find out a closer relationship between electricity and life, but we are not at present justified in making such a statement. What I am going to endeavour to do in the three brief hours allotted to me is to establish certain physical conditions with regard to the human body and to apply them in a more natural fashion than has been done by previous investigators, more from the inorganic, more from the physical than from the physiological side.

Very early in the history of electricity the physiologist seized upon it, and very properly; distinguished men seized upon it and used it as a means of causing irritation in nerve and muscle. Having referred to the experiments with the galvanoscopic frog, Dr. Stone said that was too delicate a test, was an unmeasurable test. The induction coil is a very complicated electrical apparatus, the actual working of which has hardly been fathomed by physicists. We have lately been able to find an apparatus which would, to a certain extent, supplant the galvanoscopic frog, an equally delicate instrument, and we are beginning to get at the action of the induction coil. Now, I will only say how we can replace the galvanoscopic frog by the newly-invented telephone, and so find out more than we previously could regarding the currents that pass through the induction coils. I have here a Du Bois-Reymond coil, and I have laid on an electrical wire along the room to a series of telephones, and when I put the battery on I shall be able to make the telephones respond, jar and jerk, as does the galvanoscopic frog. Having shown the experiment, Dr. Stone continued: I shall refer to it in the third lecture, but I wish to show you that the telephone can be used with induced currents as a galvanoscopic frog. The first discoverer of this fact was Prof. Hughes.

I propose to occupy myself, in the short time at my disposal, with the resistance of the human body. There were a great many early discoverers that the human body places some obstacles in the course of an electrical current, and the technical term for this condition is resistance. Volta himself worked at it, and a number of observations have been made by distinguished men. But the first serious attempt to obtain the real resistance of the human body was by Edouard Weber and by Wilhelm Weber, of Gottingen. I have an account of that in a work by Du Bois-Reymond, but time does not allow of my quoting it. The best work among the early writers upon the subject is undoubtedly that of Du Bois-Reymond. All those early investigations turned out unsatisfactorily. Even Du Bois-Reymond himself could not account for it, and he has written somewhat to the effect that he has given it up in despair. In this very treatise of which I have spoken, he says: "In no part of this province do we meet with such unaccountable freaks of experiment. The proving of the most insignificant fact often calls forth efforts out of all proportion, and whilst in other cases the discovered contrivances lasted for long hours of experiment, we are now in the position that a single experiment demands preparations which, if not complicated, will necessitate detailed preparations; whereby these experiments are the most lengthy one can imagine."

Among the early investigators in this direction were Volta, Humboldt, Lenz, Gilbert (1801), Ptschelnikoff, Fechner (1839), Edouard Weber and Wilhelm Weber (1835), Comte du Moncel; but their careful experiments are deprived of value by the fact that the polarisation of the electrodes was not taken into consideration. There is another reason why these early observers failed entirely. That is, that Weber and those who followed him took the view that it was a matter of indifference whether you measured the resistance of the human body with an ordinary low tension current from a battery, or with the high tension, secondary, induced or momentary current from an induction coil. I believe I may claim for myself the small merit, if merit it be, of having found that the resistance of the human body with the ordinary battery current and with the induced current is totally and entirely different; I shall be able to show you it is very often only half and seldom more than two-thirds what it is with the ordinary battery current. For this reason I fear the observations of Weber and others must be discarded as untrustworthy; they cannot be taken as they stand.

There is a very good paper by Du Moncel in which is what I may call the first approximation to a real estimate of the conductivity, or the resistance, of the human body. It is in a wonderful paper of his on the conduction of moderately good conductors, of imperfect conductors, and he says at the end: "The conductibility of the human body, although acting very much like those we have spoken of, presents certain peculiarities." He then describes his experiment: "During the experiment I employed electrodes of platinum, which I tied pretty strongly on the internal wrist of the patient." He gives a description of the experiment, which lasted an hour and a half. The only misfortune was that, without intending any harm, he decomposed his patient—who was in this case his wife—he electrolised her. Du Moncel is gone to his rest, but the old lady is still alive and bears the traces on her wrist of the tremendous ulceration which he caused. Although he produced a great error by this electrolisation, he got an estimate which is an approximation of the real resistance of the human body. He said it was about equal to 350—and sunk to 250—kilometres of telegraph line. In those days there was a unit used in Switzerland and France, which was called the French unit, and was equal to a kilometre of iron telegraph wire. This kilometre of iron telegraph wire, four millimetres in diameter, may be taken practically as 10 ohms; therefore his estimate was from 3,500 to 2,200 ohms, a very wide margin, but the latter of the two is an approximation of what it really is. It is astonishing that he did not get a lower resistance seeing that he destroyed the epidermis and caused ulceration.

Now, what is the reason that these difficulties have existed? The moment I began to experiment I saw there were two, if not three. The first is the difficulty of making good contact, and up to lately there never has been proper contact made. The electrodes used by Du Moncel were only $4\frac{1}{2}$ centimetres by 3 centimetres each—that is, an inch and three-quarters, English measure, by an inch and three-eighths—and the proof that they were not large enough is that the density of the current was so great as to cause physical injury. Then the difficulty, first of all, is to make good contact. The human body is somewhat like a condenser or a cable; it is a mass of conducting material contained in a highly insulating envelope; indeed, so good an insulator is the skin that it is quite possible to excite a frictional electric machine by the dry palms of the hands.

Then, secondly, comes the fact that the human body rapidly electrolises. The human body, I shall be able to show you in a second lecture, is a secondary battery of no inconsiderable power, and when even a small

current is passed through it, electrolytic decomposition is set up which can be reproduced in an antagonistic current, and which, of course, modifies entirely the measure of resistance.

Besides that there is a third action. That I name in the syllabus the electro-chemical capacity. In the paper I read before the British Association at Southport I spoke of the human body as a condenser. So rapid is the progress of science that I must now modify that term. I think Prof. Hughes's brilliant researches, which have only been public within the last two months, give me a far better name for that third condition of the body which has given me so much trouble, and I shall now call it "self-induction." That, again, I must leave until a later lecture.

As to contact and the mode of investigation, it is obvious that any contact resistance from the skin must as far as possible be eliminated. We do not want to know the resistance of the skin; that can go up to any amount; it is given by the latest writer on electro-therapeutics, Dr. Rosenthal, as from 8,000 to 20,000 ohms. What we want to know is the resistance of the tissues which underlie this insulating layer. The physiological conductivity of the deeper tissues, not of the mere skin, is what we want to measure, and the fair statement is that the contact should be infinitely large, mathematically considered, compared with any current which can be sent through it. If this condition is complied with, the resistance can be brought down to something very moderate indeed. I employ, therefore—and I find I am anticipated in this, as in many other things, by Du Bois-Reymond, who lighted upon it more by accident in the beginning—simply salt and water. I tried mainly saline solutions, but thinking of lead as being a very inert body in the electrical scale, I tried two large leaden poles; and these have answered. If the patient is confined to bed I place a little salt water solution on his feet or hands, and so I get a good contact. When I have my contacts, it is important, in the next place, if I am to measure the resistance, that I should take anatomical points, so as to make sure that the same proportion of the patient is traversed by the current in every case, and I have found two very convenient indeed. One is this prominence at the wrist, the ulna, which is marked in most people, and the other is the external prominence at the ankle. The advantage is that when the patient is stripped you can take a tape and get the measurement of the human conductor certainly within a quarter of an inch. Therefore, these are the two points I generally use.

For measuring I have used in some instances Wheatstone's bridge. Any battery which is easily managed, and has a tolerably good E.M.F., will do; I now use chromic acid pure, which works better than bichromate of potash, and these cells, in good working order, may be said to have an E.M.F. of two volts each; therefore, so many batteries varies the number of volts. Their internal resistance is so very small, even compared with the internal resistance of the human body, that you may neglect it. Then, having your contact—I may say I tried a number of other methods of securing contact, but they were all more or less unsatisfactory, wet carbon, spongy fibre, and I was also allowed by some students to introduce a surgical instrument and so get through the epidermis; but this hurts very much, and very few would stand it, so I came back to the leaden contacts. Besides that, I have to say, in what directions do we want to pass the current? There are four directions in which it is worth while to pass the current: from hand to hand is commonly used, but from foot to foot involves a greater amount of tissue, so that is the most interesting to us; but from hand to foot is of very great value. You must pass it through limited parts of the body, and from foot to foot, and from hand to hand, and then from foot to hand on either side will give you a very good estimate of the resistance through the main tissues of the body.

As regards length, it is in the legs that a tall man differs most from a short man. I have had the opportunity of measuring some of very greatly varying heights, and the results with some of the most remarkable I have tabulated on the board.

	Height.	V to M.	R.	
			Foot to Foot	Foot to Hand.
	ft. in.	ft. in.	ω	ω
Mr. Todd	5 6	5 9¾	945	1320
Mr. Shackell ...	6 3	7 0	930	1027
Hungarian Giant ...	7 6	8 7	930	1032

With regard to the method of momentary contacts, I have in circuit a Wheatstone's bridge of a rather particular form, a commutating key so as to send the current in opposite directions, and I have a double contact key as it is called, by which I can make contact through the battery, and afterwards through the galvanometer. In this way I think I shall lessen the effects of polarisation; the observations given were taken in this way, and they agree remarkably well.

An experiment upon a porter from St. Thomas's Hospital, an athletic young man, was then conducted, the measurement being taken from foot to foot, with the result that his body showed a resistance of 1060 ohms. Dr. Stone proceeded:

The reason why I use these alternating currents is because of the second difficulty, the difficulty of polarisation. Polarisation causes the resistance to rise steadily. I believe I could possibly demonstrate that if I put on this current for some little time. This polarisation is really chemical decomposition taking place inside the body, and it acts as an opposing E.M.F. For a long time I was very much troubled in this way. I could not get any readings that would agree with one another. Indeed, Du Bois-Reymond seems to have been troubled in the same way, for he ends without giving the resistance of the human body. He says, "I have not taken the trouble to ascertain the resistance of the human body," by which I really think he means he could not get any congruous readings.

So far had I reached when my friend Dr. Oliver Lodge suggested to me, "Why not use Kohlrausch's principle of the induced current, and use the telephone for a galvanometer?" This method is extremely pretty and charming, and upon it I wasted a year of work.

There is another wonderful thing, the cross results we obtained differ as much as from 1 to 2 or 1 to ½. I propose to take that very diffcult subject later, and I am now going on to speak of other methods which were suggested to me. Momentary contacts I have mentioned; alternating currents I will leave till the third lecture; I have still to speak of the second method—that of Mr. Mance, which has, I hope, solved the difficulty for me without the use of alternating currents. Sir Henry Mance, as he now is, is superintendent of the Persian telegraph system, and on May 8th, 1884, he brought before the Society of Telegraph Engineers and Electricians a method of eliminating the effects of polarisation and earth currents from fault tests. It is a very technical thing, but it amounts to this, that the cable which is leaking is liable to set up a counter E.M.F. similar to that I have named, and which I shall presently demonstrate as occurring in the human body. The body very much resembles a faulty submarine cable, and it occurred to me that this method might succeed better than the one I had wasted so much time on. I found it answer extremely well. I had some correspondence with Sir Henry Mance, who said that he made a few experiments touching the resistance of the human body, but had no leisure to continue them. From hand to hand he found the resistance from 900 to 1,100 ohms; the observed resistance was higher in consequence of polarisation, but he always corrected the results of his formulæ. He did no more than test one or two individuals. These determinations of Sir Henry Mance's were the first that could be called absolutely correct.

His method amounts to this, that instead of cutting the current as short as possible to stop polarisation, you let polarisation do its worst. and then you alter the conditions of the problem by shunting what are called the proportional coils; you change the resistance of the whole circuit, take an observation under totally different conditions, and then by cross-equating you are able to remove what is disadvantageous, leaving behind only what is really good, true gain. Mance's method was used originally on the Persian Gulf cable, and is as follows:—

Let P_1 = R of coil A; P_2 = R of coil B; R_1 = R with coil P_1; R_2 = R with coil P_2;

then $$x = \frac{(R_1 \cdot P_2) - (R_2 \cdot P_1)}{P_2 + R_2 - P_1 - R_1},$$

or $$x = \frac{A - B}{C}.$$

I will endeavour to take a test on this method. Here I have two proportional coils which are united by a cross-piece, so that I can switch them on at one motion. Dr. Stone then carried out the experiment on the hospital porter, getting a resistance in the first place of 1,070 ohms, rising afterwards about 10 ohms in consequence of polarisation. In a previous experiment with the same patient, he stated, the resistance rose 7 ohms. Continuing, he said:

There is a very good diagram there, made independently from me, in which the volts are shown on one side, the current in ampères on the other; the E.M.F. was steadily increased so as to show the effect of it. The first two observations were made by Mr. Lant Carpenter and Mr. Wilkinson, independently of me. The third was made by me on the same patient some time before, and the agreement is really most satisfactory. The resistance from foot to foot began at 1,194 ohms,

E.M.F. volts.		Resistance, ohms.	Current, ampères.
2	1st minute 4th „	R = 1194 R = 1230	·0016
4	4th „	R = 1155	·0034
8	1st „ 4th „	R = 1130 R = 1160	·0069

and went up after four minutes to 1,230. Four cells were put on, and seemed to break down the resistance, which was then 1,155 ohms. These observations were made by taking the deflections of a galvanometer. Eight volts were put on, and the resistance was 1,130 ohms, rising after four minutes to 1,160.

There comes out of this, putting aside the fact that the resistance of the body is infinitely less than has been thought, a question which has often been asked me, does the size not make a very great difference? If the patient be healthy, well-nourished, and the muscles in good condition, it does not. I can trace here a very distinct mechanical law, that as is the length of the levers so will be the cross-section, the bulk, or the diameter, of the muscles that move them. So it appears in these three men of very different statures, every one of them active, vigorous men, and oddly enough the smallest man gives the highest resistance by a little, but from foot to foot there is only 945 against 930. The Hungarian giant, a splendid man, well-trained, gave exactly the same figure as Mr. Shackell, who, I believe, at football and other games, was equally active. A difference is shown from foot to hand: you have to pass through a very narrow conductor in the arm, and so the big man comes out a little more, but only 5 ohms. This establishes a physiological fact, which is extremely important. I do not claim this as universal; in diseased tissues, and in extremely fatty bodies, of course considerable differences take place. In ordinary health, however, you may say that the height does not materially modify the resistance.

To draw to my conclusions, we must not calculate, as lately we have been doing a great deal too much, upon the safety of currents merely on the insulating power of the epidermis, which may be accidentally broken down by so trifling a matter as the saturation of the epidermis with salt and water. Many sad accidents are undoubtedly due to the fact that for a moment the insulating power of the skin is broken down and a strong current passes.

Mr. Cunynghame finds the resistance 2000 ohms between hand and hand immersed in acidulated water. He has written me a letter in which he says: "May I suggest that there is one aspect of the question which I hope you will see your way to treat, that is, the real limits of safety for dynamos as to E.M.F. and intermittency, as the subject has never been adequately treated, and the Board of Trade is much at sea on the question, particularly with regard to the limits of safety." They at present put down 200 volts as the outside limit to be allowed, but dynamos now running go up to 800 volts. No doubt, as time goes on, there will be more unfortunate men who will put their hands on the two brushes of the dynamo and will meet with sudden death. At present accidents occur more serious than we know of, for I am afraid there is a trade coalition to keep them concealed. I think this, we, as physicians, ought to stand out against. It is thought that it will injure the future of the electric light commercially if these accidents are known, so they are explained away or hushed up by compensation or a present. This, I believe, is a false system altogether.

Now we come to the consideration of whether these observations may be made useful in the treatment of diseases, and I will give a sketch of how the facts ascertained may be utilised, to show you that this enquiry is not unpractical. It has given me great trouble to discover—and I cannot say that I have settled the point to my own satisfaction—whether the human body acts as a fluid conductor or as a solid. Du Moncel and Du Bois-Reymond take it for granted that it is fluid by virtue of the water it contains. I am doubtful of this; indeed, certain observations I have made seem to point the other way. I have also found that the occurrence of dropsy, when the tissues are water-logged, enormously reduces the resistance. The resistance in a dropsical patient sunk to one-half and remained there. Then I find that degenerated tissue, and tissues where muscular fibre has been replaced by common fibrous tissue, have become infinitely less resistant. Muscle would, therefore, seem to be not so good a conductor. Then, I had six cases of hemiplegy, and in all these cases the hemiphlegic side resisted less than the fibrous tissue or healthy side, being, therefore, a better conductor than the side on which the muscle was sound. In one case the resistance was 420, in others 350, 360, 120, 550, 730 ohms, all in the same direction, and this surely can not be all wrong. There will be some evidence of its being an instrumental error, but I think I may take it that paralysed muscle conducts even better than healthy muscle.

I think we may say that certain metallic impregnations do influence the conductivity of the body. I have had a large number of cases of mercury, lead and copper impregnations, and have been working, hitherto unsuccessfully, with silver. The lead was not very marked in its effects, but mercury produced a considerable difference, and in one case of copper impregnation I found that the right hand, with which the coppersmith used his hammer, conducted much better than the left, which he did not use so much in his trade. In this case I was able to complete the observations, and by examining the urine proved that he was impregnated with copper; I extracted three milligrammes of copper.

The point of temperature I am hardly prepared to speak with certainty upon, but I have recorded the actual figures in a very curious case, and I found that when the body was hot the resistance, instead of being less, was greater.

THE STRANGE HISTORY OF A DYNAMO,

As told by itself to

A. DYNAMICABLE.

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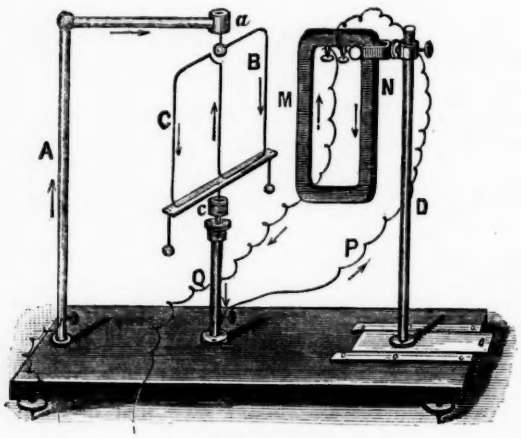
(*Continued from page* 328.)

I HAD almost forgotten to tell you, for I am but little used to talking of myself (except to myself), that this happened, to the best of my remembrance, in the month of July, 1820. This germ, from which I was gradually developed, was not allowed to remain in a chrysalis state, for a few months later on a French scientist of great eminence, Ampère by name, found that it possessed greater vitality than Œrsted gave it credit for. The Frenchman, going further, discovered not only that a galvanic current moved a magnetised needle placed within the range of its magical influence, but also that two currents would reciprocally act one upon the other. You will naturally infer from this that one of the wires or circuits which the currents traverse must be arranged in such a manner that it is free to move, and I cannot call to mind a better way of making this clear to the public than by briefly describing the modified and improved form of Ampère's apparatus, a sketch of which I will now trace for you.



AMPERE'S APPARATUS.

It consists of two brass columns, A and D, having between them a shorter one. On the frame, M, N, is a coil of wire and this can be adjusted to any height and position by means of the sliding clamp. The short column is hollow and carries a brass tube terminating in a mercury cup, *c*. On column A is another similar cup, *a*, having in the bottom a tiny aperture through which passes the point of a sewing needle fixed to a little copper ball. The movable part of the circuit is a wire shown by the arrows and extending from *a* to *c*. Now a strong galvanic current ascending by column A to the cup, *a*, traverses the movable circuit or wire, B, C, reaches the cup, *c*, goes down the central column, through the wire, P, to the coil, M, N, returning to the source of electrical energy or battery by the return wire, Q. Now, when the current passes, the wire, C, B, will be freely moved, thus showing that currents act inductively upon each other as well as upon magnetised needles.

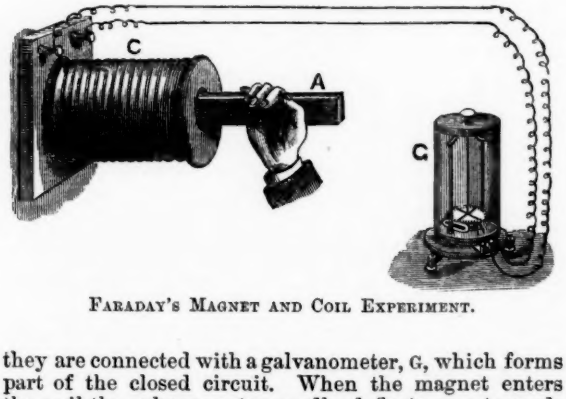
Almost simultaneously, if my memory serves me aright, Arago, a famous physicist, added yet another link to the chain of my story by observing that a galvanic current imparted magnetic properties to iron or to steel which had not previously been magnetised. You may easily verify the truth of this, for if you take a rod of iron or steel, say, four inches in length and half-an-inch in diameter, and coil round it from end to end cotton-covered or otherwise insulated copper wire, you will find that on connecting the ends of this wire with a powerful galvanic battery, the iron or steel has become highly magnetic, and that it will attract and hold with great tenacity any other piece of iron or steel which may be brought near to its ends.

Why copper wire? you say. Well, this is to a certain extent a digression from the main point at issue; but in a few words I may tell you that copper is, with the exception of silver (the price of which, of course, prohibits its use for anything but special purposes), the best conductor of electricity which we have at our command. Like water or steam passing through a pipe, electricity meets with a certain resistance in traversing a conductor, and copper offers the path of least resistance. To make my meaning more clear, a given current will pass as readily, and with as little loss, through a copper wire of one square inch in section as through an iron conductor of seven times that sectional area.

To return to myself: for the next ten years nothing was done to promote the growth of the seed then sown, so far as I am personally concerned, although in other ways the facts I have thus far related were turned to full advantage; but at the end of this period of enforced inactivity the great English philosopher, Faraday, to whom I consider you and I owe a deep debt of gratitude, which, however, *you* may not fully realise, discovered that a magnet could bring into existence an electric current; in other words that a magnet could, as well as a galvanic battery, produce a current of electricity in a closed circuit. It was through his untiring labours, pursued in such a true spirit of scientific investigation, and without that love of emolument so prevalent in our days, that the germ became possessed of definite form and wondrous vitality, whereby I am now enabled to place at the service of man that giant force with which I am endowed. Whilst upon this topic I may add that I shall have occasion to refer to another Englishman whose work on my behalf has not yet received the acknowledgment which is justly its due.

I have at times, when by myself and for the moment in a state of inactivity, pondered over the vicissitudes of my infancy and wondered how it was that Arago missed that which was so nearly within his grasp, for does it not seem strange, and in this I think you will agree with me, that the eminent Frenchman failed to see the converse of his brilliant discovery? However, English people must feel justly proud in knowing that it was reserved for their great fellow-countryman to fall upon that,—not by chance, be it known, but by that process of true philosophical reasoning which has rendered his name immortal.

Faraday's discovery is very aptly conveyed to the understanding by the following beautiful experiment. If a bar magnet, A, is pushed into a coil, C, of insulated or covered wire an electric current is generated if the circuit be closed, *i.e.*, when the ends of the coil are joined together or, as shown in the figure, when



FARADAY'S MAGNET AND COIL EXPERIMENT.

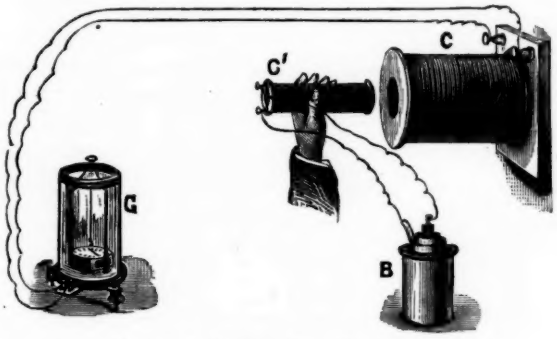
they are connected with a galvanometer, G, which forms part of the closed circuit. When the magnet enters the coil the galvanometer needle deflects, say, towards the right; if the magnet be held stationary the current vanishes, and the needle of the galvanometer returns to its normal position or zero; when the

bar is withdrawn another current is generated, but in an opposite direction to that of the first; the current again has but a momentary existence, and the galvanometer needle once more returns to its rest.

From this, then, you will readily conceive that if the magnet be pushed into and withdrawn from the coil with sufficient rapidity, a practically continuous supply of electrical energy might be obtained, but from currents flowing in *opposite* directions. I wish to impress this very strongly upon your memory for reasons which will hereafter appear.

I am afraid that my story will take longer in telling than I had anticipated if you do not allow me to proceed unquestioned. What will the public understand by a galvanometer? Well, there are galvanometers and galvanometers, but it will suffice to know that it is a delicate apparatus for detecting the presence of electrical currents and the direction in which they flow, by the movements of a finely poised magnetic needle which is influenced by a coil of wire through which the currents are made to pass. Such an instrument, indeed, is figured on the extreme right of the sketch I have just limned for you to illustrate the discovery of Faraday.

I have already made it known to you that galvanic currents can act upon one another, but in order that I may be clearly understood I think it necessary that I should again refer to this point and show you yet another illustration. It will not cause you any surprise, knowing that a magnet can induce currents in a coil of wire, to learn that if instead of the magnet we employ a second coil, C_1, which will go loosely into the first, C, and through which *a current is permanently flowing* from the galvanic cell, B, similar effects will be produced in our original coil upon the insertion and withdrawal of the smaller one to those observed in the case of the magnet. I think that I have



Faraday's Double Coil Experiment.

now sufficiently made clear the discoveries which made my existence a *fait accompli*, so I will now ask your forbearance if I return for one moment to the ground we have so far covered. I do so simply to bring through your aid more prominently before the reader's notice that:—

1st. *A galvanic current passing through a coil of wire surrounding a rod of iron will make the iron, so long as the current continues, a powerful magnet.*

2nd. *That this same magnet can be utilised to produce powerful currents of electricity.*

How these facts have been developed will become apparent upon studying my progress from the time when I first felt myself able to create a ripple of astonishment throughout the scientific world to the present day.

(*To be continued.*)

Electric Bells and Speaking Tubes.—The Stockport Infirmary has been fitted up with electric call bells and speaking tubes on the system of Messrs. Durham and Co., and many architects of the town and neighbourhood have pronounced in their favour. They are also extensively laid in private residences and shops.

A VISIT TO MESSRS. CROMPTON'S WORKS.

The students of the Institution of Civil Engineers, accompanied by Mr. James Forrest, the secretary, visited Messrs. Crompton's electric light works at Chelmsford, on Wednesday, the 7th instant.

They commenced their inspection of the works in the heavy machinery department; here they had opportunities of examining the various parts of dynamos in all stages of construction.

In this department, among the numerous other large tools which were objects of considerable attention, was a circular saw used in cutting up 8 inch square bars of cold wrought iron; a large new milling machine, manufactured by Messrs. Kendall and Gent; also a large planing machine, used for all heavy dynamo bed plates.

The testing department was found to be well fitted with all the most modern appliances, including very large rheostats, measuring instruments, photometers, &c. Attention was drawn to a three-cylinder compound Willans' engine, driving direct a large Crompton dynamo; this set was of the type exhibited at the International Inventions Exhibition, and was here used for doing all electrical work required in the works for shop lighting, both by arc and incandescent lamps, and also for driving motors working the fans in the smiths' shops, and all the shafting in the pattern shop.

In the bobbin shop the visitors were enabled to examine armatures of every size and description, in various stages of completion, the sizes of these varying from an armature able to work 12 lamps at 2,000 revolutions, to one capable of generating 100,000 watts at 400 revolutions.

On this floor, also, projectors of all sizes, and hand lamps of English and other patterns, were on show. The new pattern of high-pressure steam valve, which the firm had just completed, was very favourably commented upon. In the new erecting shop was seen three complete combined plants, each capable of giving 100,000 watts at about 400 revolutions; one of these being specially put under steam for the inspection of the visitors.

Prominent among other features of interest which cannot be detailed at any length, were the fittings for a complete set of gear necessary for a lightship; these embraced dynamos, engines, boilers, glazed lanterns, containing four arc lamps, suspended on gimbals, &c.

The whole works, which employ upwards of 400 men, show in every department the steady progress which this branch of engineering is now making; and the inspection occupied the whole afternoon.

DYNAMO TESTS.

The dynamo tests given on another page show that it is possible, by combining a direct-acting engine running at a fairly high speed with a good dynamo, to obtain in the circuit between the machine terminals, a return in electrical work of over 70 per cent. of the indicated horse-power of the engine. When the installation at Victoria Station was tested, some time ago, it was shown that from belt driving an electrical return of 65 per cent. of the I.H.P. could be obtained, the friction of the belts in that case absorbing a fair share of the work wasted. Now, by direct driving the proportion of the I.H.P. appearing in the circuit has been raised to a mean value of 74 per cent., the speed of the dynamo having been at the same time reduced. This is a very good efficiency, but it appears to us that the final results as given in Table VI. call for some explanation, the figures being, to say the least of it, arranged in a rather strange way. One would naturally expect that the maximum I.H.P. would be shown when the electrical output reached a maximum, but this is not the case in the table referred to. For instance, at 5 : 55 the electrical horse-power reaches 95·65, that indicated being 118·05, whereas at 6 : 35 the

I.H.P. increases to 130·47, and the E.H.P. falls to 89·05. In the former case the commercial return is said to be 79·2 per cent., while in the latter case it is 66·5 per cent. Some explanation of these anomalous results can doubtless be given, and it would be well if, at the same time, we have some explanation of the extraordinary and erratic variations in the efficiency in a short two hours' run. Seemingly, but little importance can be attached to the mean value of 74 per cent. when the efficiency fluctuates between such wide limits as 66·5 and 79·8, and with a knowledge of such strange behaviour as that indicated below it is difficult to determine exactly the value to place on the figures. Taking the E.H.P. appearing at the brushes we notice that between the readings taken at 5 : 30 and 5 : 35 there is in the E.H.P. a fall of nearly 10, while in the I.H.P. the fall is only 4. Again, in the next five minutes, between 5 : 35 and 5 : 40, the I.H.P. falls by 6, while the E.H.P. practically undergoes no change. The strangest phenomenon occurs at half-past six, for between the readings taken then and at 6 : 35 it seems that the I.H.P. *increases* by about 7, while the E.H.P. actually *decreases* by about 3. Finally, the I.H.P. at 7 : 25 makes a last effort and increases by 9 in the remaining five minutes, while the E.H.P. remains practically *in statu quo*. We are not necessarily questioning the accuracy of the results as to efficiency. We only wish to know why they vary so, and whether 66, 70 or 74, is to be taken as the actual efficiency for continuous long runs. It is possible that these results may be due to inefficient or intermittent engine lubrication, but we wait for explanation.

THE CROMPTON DYNAMO.

REPORT ON ECONOMY TEST OF A CROMPTON DYNAMO DRIVEN DIRECT BY A WILLANS HIGH SPEED ENGINE.

The object of the trial was :—

1. To ascertain correctly the consumption of water per I.H.P per hour of the new type of tandem compound high speed engines, recently introduced by Willans and Robinson of Thames Ditton.

2. To ascertain what percentage of the I.H.P. in the engine cylinders can be obtained as useful electrical H.P. at the terminals of the Crompton dynamo driven direct by one of these engines.

3. The above data being correctly ascertained, to show the consumption in pounds of water, and hence the pounds of coal per useful electrical H.P. per hour.

Mr. J. Macfarlane Gray, Chief Examiner of Engineers to the Board of Trade, Mr. W. H. Massey, C.E., of Twyford, Berks, and Dr. Fleming, of University College, London, were invited to conduct the trials on the date on which they were to take place. Mr. Massey, being unavoidably absent owing to illness, requested Mr. E. H. Liveing to take his place. Mr. Macfarlane Gray and Mr. Liveing took charge of the indicating apparatus, measurements of water used, and all measurements relating to the engine. Dr. Fleming took all the electrical measurements, and afterwards verified the instruments used.

Description of the Engine :—The engine tested is one of Messrs. Willans and Robinson's latest design, and make. It is non-condensing and single acting, having two high pressure and two low pressure cylinders, the high pressure cylinders being 11 inches in diameter, placed on the top of the low pressure cylinders which are 18 inches in diameter both having nine inch stroke. The arrangement of this engine was fully described and shown with diagrams during the discussion on Mr. Imray's paper on high speed engines recently read before the Institution of Civil Engineers. The engine was designed to run at a speed varying from 200 to 400 revolutions, and to develop at the higher speed 140 I.H.P., with boiler pressure of 140 lbs. per square inch. As a matter of fact it will be seen from the indicator diagrams, that the engine was rather too large for this work.

The indicating gear consisted of four Crosby indicators; the high pressure indicators had 120 lb. springs, the low pressure ones 50 lb. springs. The two low pressure indicators were also arranged to indicate the variations of the receiver pressure as the under side of the high pressure cylinder being open to the receiver, the variations of pressure in the latter affect the power of the engine.

The number of revolutions was taken from a Young's speed indicator, driven directly off the engine, checked in addition by counting the revolutions with an ordinary geared speed counter (at the end of the spindle) at the time that each set of indicator diagrams was taken.

The Crompton dynamo is of the vertical type, having wrought iron magnets 24 inches wide by seven inches thick; the armature being 36 inches long and 16½ inches in diameter. One end of the armature spindle was bolted to the crank shaft of the engine by a solid steel coupling; the other or commutator end of the spindle was carried in a spherical bearing, so formed as to be easily adjusted and kept in line with the three main bearings of the engine crank shaft. This dynamo was designed to give an electrical output of 600 volts and 120 ampères at a speed of 400 revolutions. This is equal to 72,000 watts or about 97 electrical H.P.

Means adopted to ascertain the quantity of water used by the engine.—The engine was supplied by a pair of nominal 20 H.P. locomotive boilers made by Messrs. Marshall, Sons and Company, of Gainsboro', being two of the boilers usually employed for driving Messrs. Crompton's works. The ordinary feed arrangement was disconnected, and the boilers were supplied by a pair of Hancock's inspirators drawing from an iron tank, which at the commencement of the trial was filled up to a gauge mark, and at the end of the trial was again filled up to the same mark. The whole of the water passed into this tank through a barrel mounted on an accurately adjusted scale beam, so that its actual weight was taken and no calculations were necessary. The coal used during the trial was weighed, but as the boilers were not specially cleaned for the occasion, the evaporative efficiency was not high. However, the actual results obtained are noted in the tables.

Method adopted to ascertain the electrical output.—A large rheostat or resistance coil was prepared, consisting of a continuous band of wire gauze stretched tightly over a large frame, and so arranged with switches that any desired portion could be short circuited and the resistance thus varied. The conductors from the terminals were led to this rheostat, and from thence to the measuring instruments which were placed in Messrs. Crompton's test-room. These instruments consisted of two of Messrs. Crompton's current indicators specially constructed for the occasion, and carefully calibrated by Dr. Fleming by means of a Clark's standard cell, verified against those used by Lord Rayleigh in conjunction with the low resistance, also carefully determined. The current indicators were calibrated by passing the same current through them and the low resistance coil, and measuring the difference of potential at the ends of the latter by means of the said cell.

Separate Exciting.—The Dynamo, had its field magnets excited by a separate machine. During the trials this separate machine was driven by its own Willans engine, the steam for which was supplied from a separate boiler. The E.H.P. used in exciting was subtracted from the electrical output as will be hereafter shown.

Electrical Measurements of Dynamo.

Resistance armature, hot	=	·255	ohms.
Resistance magnet coils, hot...	=	0·33	ohms.
Loss in armature at 120 ampères	=	30·6	volts.
Loss in magnet coils at 64 ampères exc. cur.	=	21·1	volts.
Watts expended in armature ...	=	30·6 × 120 =	3,670
Watts expended in exciting ...	=	21·1 × 64 =	1,350
Watts in external circuit, *i.e.*:			
Useful out-put	=	600 × 120 =	72,000
Total watts		=	77,020

Percentage of total electrical power in ex. circuit, 93·5 per cent.

It was arranged that the I.H.P. should be worked out from the indicator diagrams by Mr. Macfarlane Gray and Mr. Liveing independently.

Tables I. to III. give the results worked out from 48 diagrams by the former, who employed a planimeter.

TABLE I.

Time.	Planimeter.	Difference.	Mean pressure.	Rev. ÷ 2.	I. H. P.
A. L.	1302	...	...	...	...
5.40	1321	19	7·6	172	9·28
...	1361	40	16·	...	58·65
5.45	1380	19	7·6	189	10·2
...	1420	40	16·	...	64·29
6.00	1439	19	7·6	174	9·40
...	1485	46	18·4	...	68·25
6.05	1504	19	7·6	176	9·51
...	1553	49	19·6	...	73·44
6.20	1571	18	7·2	175	8·95
...	1620	49	19·6	...	72·96
6.25	1639	19	7·6	176	9·51
...	1681	42	16·8	...	63·00
6.40	1702	21	8·4	170	10·15
...	1746	44	17·6	...	63·75
6.45	1765	19	7·6	163	8·80
...	1813	48	19·2	...	66·60
7.00	1833	20	8·0	176	10·00
...	1880	47	18·8	...	70·50
7.05	1900	20	8·0	165	9·38
...	1948	48	19·2	...	67·35
7.20	1965	17	6·8	175	8·44
...	2013	48	19·2	...	71·40
7.25	2033	20	8·0	179	10·16
...	2081	48	19·2	...	73·20

Table IV. gives the results worked out from 24 diagrams only by the latter, who used scales.

Table II.

Time.	Planimeter.	Difference.	Mean pressure.	Rev. ÷ 2.	I. H. P.
B. L.	2081	...	...	...	...
5.30	2102	21	8·4	165	9·84
...	2151	49	19·6	...	68·9
5.35	2169	18	7·2	157	8·03
...	2218	49	19·6	...	65·5
5.50	2235	17	6·8	180	8·68
...	2281	46	18·4	...	70·6
6.10	2300	19	7·6	168	9·01
...	2349	49	19·6	...	70·5
6.15	2369	20	8·0	182	10·34
...	2416	47	18·8	...	72·8
6.30	2435	19	7·6	177	9·56
...	2484	49	19·6	...	73·9
6.35	2504	20	8·0	177	10·05
...	2558	54	21·6	...	81·3
6.50	2579	21	8·4	168	10·05
...	2625	46	18·4	...	65·8
7.10	2646	21	8·4	162	9·68
...	2691	45	18·0	...	62·0
7.15	2709	18	7·2	155	7·92
...	2756	49	19·6	...	64·7
7.30	2778	20	8·0	174	9·89
...	2828	50	20·0	...	74·1

Table III.

Time.	Planimeter.	Difference mean pressure.	Rev. ÷ 2.	I. H. P.
B. H.	2120	...	...	...
5.30	2151	31	165	36·3
5.35	2181	30	157	33·5
5.45	2206	35	189	33·6
5.50	2237	31	180	39·6
5.55	2269	32	180	40·8
6.15	2300	31	182	40·0
6.20	2325	25	175	31·1
6.30	2356	31	177	38·9
6.35	2388	32	177	40·2
6.50	2421	33	168	39·4
6.55	2450	29	155	31·9
7.10	2482	32	162	36·8
7.15	2512	30	155	33·0
7.30	2545	33	174	40·8
A. H.	...	...	...	...
5.40	2573	28	172	34·2
6.00	2600	27	174	33·4
6.05	2628	28	176	35·0
6.10	2656	28	168	33·4
6.25	2683	27	176	33·7
6.40	2713	30	160	34·1
6.45	2742	29	163	33·6
7.00	2771	29	173	36·2
7.05	2808	29	165	34·0
7.20	2827	27	175	33·6
7.25	2854	27	179	34·3

The slight difference in the measurement produces a divergence in the final result, as follows :—

Mr. Macfarlane Gray shows the mean I.H.P. during the experiments to be 113·98 (and the water evaporated per I.H.P. per hour 22·95 lbs.).

Mr. Liveing shows a mean I.H.P. during the experiments of 110·76 (and the water evaporated per I.H.P. per hour 23·66 lbs.).

The difference is not due to the selection by Mr. Liveing of 24 in place of the whole 48 diagrams, for the same 24 diagrams taken at Mr. Gray's measurement give a mean of 113·26 H.P. against 113·9 H.P. for the whole 48.

Table V. gives Dr. Fleming's measurements of electrical H.P., each of these measurements being taken simultaneously by signal with the corresponding set of indicator diagrams.

Table VI. is compiled from the former Tables for the purpose of showing what percentage of the I.H.P. in the engine cylinders is obtained as useful electrical H.P. at the terminals of the dynamo, and diagram No. VII. shows the same graphically.

For the purpose of compiling Table VI. and Diagram VII. the mean of Mr. Macfarlane Gray's and Mr. Liveing's figures has been taken.

The E.H.P. absorbed in exciting is deducted from the E.H.P. shown on Table V., as would have been the case if the dynamo had been self-exciting and the net E.H.P. is shown in column 5 of Table VI. The efficiency in this table varies from 79 to 66 per cent., the mean throughout the trial showing 74·05 per cent. of the I.H.P. given off as net useful E.H.P. at the terminals of the dynamo.

Table IV.

Willans Engine Tests, Chelmsford, December 12th, 1885.

Diagram.	Time.	Revolutions in half minutes.	Mean pres. of low pres. cylinder.	H.P. of do. × by 2.	Mean pres. of receiver.	H.P. of do. × by 2.	Mr. Gray, by Planimeter, Mean pres. of low pres. cylinder.	H.P. of do. × by 2.	Mr. Gray, by Planimeter, Mean pres. of receiver.	H.P. of do. × by 2.
A L			lbs. sq. in.		lbs. sq. in.		lbs. sq. in.		lbs. sq. in.	
1	5.45	189	16·35	65·65	7·34	9·85	16·0	64·29	7·6	10·2
2	6.5	176	18·38	68·73	7·41	9·26	19·6	73·44	7·6	9·51
3	6.25	176	16·81	62·85	7·59	9·48	16·8	63·00	7·6	9·51
4	6.45	163	18·48	63·99	7·65	8·85	19·2	66·60	7·6	8·80
5	7.5	165	18·60	65·20	7·63	8·93	19·2	67·35	8·0	9·38
6	7.25	179	18·40	70·17	7·38	9·38	19·2	73·20	8·0	10·16
Mean	...	...	...	66·1	...	9·29	...	67·98	...	9·59
B L										
1	5.35	157	19·30	64·38	7·70	8·58	19·6	65·50	7·2	8·03
2	5.50	180	17·55	67·12	7·46	9·53	18·4	70·60	6·8	8·68
3	6.10	168	19·27	68·80	7·55	9·00	19·6	70·50	7·6	9·01
4	6.35	177	21·05	79·15	7·95	9·99	21·6	81·3	8·0	10·05
5	6.50	168	19·50	69·60	8·58	10·23	18·4	65·8	8·4	10·05
6	7.15	155	18·75	61·75	7·22	7·94	19·6	64·7	7·2	7·92
Mean	...	...	...	68·4	...	9·21	...	69·7	...	8·95

			High pres. cylinder.	Pres. of do. × by 2.			High pres. cylinder, Mr. Gray.	H.P. of do. × by 2.		
A H			lbs. sq. in.				lbs. sq. in.			
1	5.40	172	27·10	33·09	...	...	28	34·20	...	...
2	6.0	174	26·35	32·55	...	...	27	33·40	...	...
3	6.20	175	26·25	32·61	...	...	25	31·10	...	...
4	6.40	170	29·00	35·00	...	...	30	34·10	...	...
5	7.0	176	27·60	34·48	...	...	29	36·20	...	...
6	7.20	175	25·60	31·80	...	...	27	33·69	...	...
Mean	...	...	...	33·25	...	...	...	33·7	...	...
B H										
1	5.30	165	30·30	35·49	...	...	31	36·30	...	...
2	5.50	180	29·70	37·95	...	...	31	39·60	...	...
3	6.15	182	28·60	36·95	...	...	31	40·00	...	...
4	6.30	177	29·45	37·00	...	...	31	38·90	...	...
5	6.55	155	28·85	31·74	...	...	29	31·90	...	...
6	7.15	155	29·52	32·49	...	...	30	33·00	...	...
Mean	...	...	...	35·27	...	...	...	36·60	...	...

Table V.—Dynamo Economy Trials.

Time.	Corrected current.	E.M.F. corrected to brushes.	Watts.	E. H. P.
5.30	124·3	530	65,879	88·31
5.35	119·1	492	58,597	78·53
5.40	120·	487	58,440	78·34
5.45	124·3	522	64,884	86·97
5.50	120·	501	60,120	80·59
5.55	129·5	551	71,354	95·65
6.0	123·1	513	63,150	84·65
6.5	125·3	522	65,406	87·68
6.10	124·3	492	61,155	85·02
6.15	129·5	524	67,858	90·06
6.20	127·4	508	64,719	86·75
6.25	123·1	475	58,472	78·38
6.30	130·5	528	68,904	92·36
6.35	129·5	513	66,433	89·05
6.40	124·3	496	61,652	82·64
6.45	124·3	481	59,788	80·14
6.50	126·3	497	62,771	84·14
6.55	121·2	465	56,358	75·57
7.0	131·5	522	68,643	92·01
7.5	128·4	496	63,686	85·37
7.10	123·1	461	56,749	76·07
7.15	122·2	455	55,601	74·53
7.20	129·5	511	66,174	88·70
7.25	129·5	508	65,786	88·18
7.30	129·5	512	66,304	88·89
			Total	2118·58
			Mean	84·74

TABLE VI.—COMBINED ECONOMY TRIALS.

Time.	Mean I.H.P.	Electrical H.P.	Extg. electrical H.P.	Electrical H.P. corrected.	Commercial efficiency.
5.30	111·74	88·31	1·9	86·41	77·3
5.35	107·74	78·53	1·79	76·74	71·2
5.40	101·57	78·34	1·63	76·71	75·7
5.45	106·76	86·97	1·28	85·69	79·8
5.50	...	80·59	1·28	79·31	...
5.55	118·05	95·65	1·9	93·75	79·2
6.0	110·62	84·65	1·9	82·75	74·9
6.5	115·47	87·68	1·69	85·99	74·5
6.10	...	85·02	1·53	83·49	...
6.15	117·50	90·06	1·95	88·11	75·1
6.20	113·76	86·75	1·79	84·96	74·8
6.25	106·3	78·38	1·33	77·05	72·8
6.30	123·26	92·36	2·02	90·34	76·
6.35	130·47	89·05	2·26	86·79	66·5
6.40	108·45	82·64	1·85	80·79	74·2
6.45	108·0	80·14	2·15	77·99	73·
6.50	117·24	84·14	2·21	81·93	70·
6.55	...	75·57	1·9	73·67	...
7.0	115·84	92·01	2·1	89·91	78·
7.5	109·48	85·37	2·26	83·11	76·6
7.10	108·48	76·07	1·9	74·17	68·2
7.15	103·9	74·53	1·9	72·63	70·
7.20	112·54	88·70	1·85	86·85	77·1
7.25	115·7	88·18	1·63	86·55	75·
7.30	124·79	88·89	1·79	87·10	69·8
Total ...	2477·67	2118·58	45·71	2072·79	1629·1
Mean ...	112·62	84·74	1·83	82·91	74·05

It was originally intended to make the trial of four hours' duration, but it was found difficult at first to make the times of the indicator diagrams coincide exactly with those of the electrical readings. The early ones were therefore rejected, and those of the last two hours only taken. It will be seen from the diagram, No. VII., that there was considerable variation in the H.P., the cause being that both the large engine and the exciting engine were incomplete, being intended for use with electric governors, which were not ready in time for the trials, moreover, the load being a heavy one for the boilers, the steam pressure at first was not kept very regularly. Owing to the system adopted of weighing the water it was possible to obtain with the utmost exactness the quantity used during the two hours of the trial, but this could not be the case with the coal, as the quantity was weighed out for the whole run. However, dividing the total weight of water evaporated during the four hours by the coal consumed during the same period we find that 7·42 lbs. of water only were evaporated per lb. of coal. The total weight of water evaporated during the actual trial, lasting 2 hours 2 minutes, was 5,320 lbs., therefore, the results in lbs. of water per H.P. and per E.H.P. per hour—viz., 23·2 lbs. and 31·31 lbs. respectively—are exceedingly good, in fact there are no published results which show even an approximate approach to this measure of steam consumption per E.H.P.

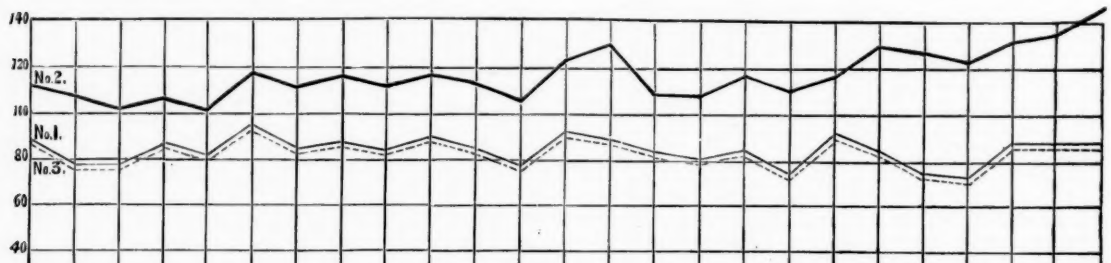
Good though these results are, it would hardly be fair either to the engine or dynamo to take them as representing their maximum efficiency, for the boilers were not sufficiently powerful for the work and could not be cleaned for the trials; it is, therefore, more correct to eliminate the boilers from the calculation by taking the steam used, instead of the coal, though even then an error creeps in, as the steam was probably rather wet from insensible priming, due to the forcing of the boilers. Moreover, the condensation in the steam-pipes was considerable, owing to the temporary nature of the connections. When these drawbacks are taken into account, and it is further considered that it was apparent from the indicator diagrams taken during the trial that far greater economical results would have been obtained at a higher H.P. had the boilers permitted it, there seem fair grounds for expecting a consumption little exceeding 20 lbs. of steam per I.H.P. per hour, or 27 lbs. per E.H.P. per hour, and this with a good boiler is equal to 2 lbs. and 2·7 lbs. of coal respectively. Boiler pressure, 130 to 140 lbs.

In cases where a condenser can be used, there would be a further increase in the economy.

These trials show that the view held for so many years that a high-speed engine must necessarily be wasteful, must be definitely given up, for in this case we have a high-speed engine showing under not the most favourable circumstances an economical use of steam which need not fear comparison with that of any other slow speed steam engine; but it is capable, as has been shown, of still further improvements.

The bearing of this fact upon the future of electric lighting is most important. A great step has been made in the direction of economical production of electrical energy from the fuel, and it seems probable that the typical dynamo of the future for large installations must be one driven direct by a high-speed steam-engine of from 150 to 200 horse-power.

(Signed) J. MACFARLANE GRAY.
J. A FLEMING.
E. H LIVEING.



CURVES OF ELECTRICAL OUTPUT AND MECHANICAL INDICATED HORSE-POWER OF VIENNA DYNAMO (No. 1123) AND EXCITER.

No. 1 = Electrical H.P. of $\frac{7·2}{600}$. *No. 2 = Indicated H.P. of large Willans Engine. No. 3 = Electrical H.P. of* $\frac{7·2}{600}$,*—Exciter E.H.P.*

THE JUDGMENT IN THE TELEPHONE CASE.

THE *Pall Mall Gazette* says:—"Mr. Justice North delivered on Saturday last a judgment in a telephone suit which indicates a strange perseverance in the mischievous practice of enlarging in favour of a powerful monopoly the claims of a patentee. The patentee in this case was the notorious Edison, whose sole claim respecting that part of the telephone which goes by his name is defined by the words, 'I claim as my invention the combination' (in this instrument) 'with a diaphragm or tympan of electric tension regulators.' The instrument of Edison consists of several parts—'the diaphragm,' the 'tension regulator,' the mouth 'tube,' and the 'adjusting screw;' but he disclaims any right to the latter details. A Mr. Bassano, a small telegraph engineer of Derby, had ingeniously devised a telephone in which the mouth tube was retained, with the regulator, but without the diaphragm. Mr. Justice North has, however, decided that because a tube can be made to discharge the functions of the diaphragm, therefore it is a diaphragm, and condemned Mr. Bassano in a long-winded judgment requiring nearly an hour for delivery. We recommend to Mr. Justice North the following argument: A horse can be used in combination with a cart, but a steam engine can be used to discharge the same functions as the horse. Therefore the man who uses a steam engine infringes the use of a horse. Only in this case the combination cannot be patented.

"The extraordinary reason given by Mr. Justice North for thus stretching beyond all right and reason the meaning of the perfectly plain term 'diaphragm' was that Edison, being the original and first inventor of the telephone, had the utmost right to protection. The real fact which Mr. Justice North ought to have known is this: that in 1876, when Graham Bell's telephone was

making a sensation in the States, the then president of the Western Union Telegraph Company, the Hon. William Orton, came to Mr. Edison, then an operator in their employ, bringing with him a manuscript account of Philip Reis's much earlier telephone of 1861, and begged him to construct a telephone on the basis of Reis's telephone, so as to out-rival Graham Bell. Edison stated this on oath several years afterwards. Yet this is the man in whose favour Justice North stretches the term 'diaphragm' so as to include, not only a speaking tube, but everything else through or at which one can speak to a telephone. The doctrine of 'benevolent construction,' as the lawyers put it, in patent cases is always and essentially unjust. It is unjust to the patentee to interpret his claims so as to limit them to less than what he is entitled to. It is equally unjust to the public and to other inventors to widen them beyond the meaning of the inventor's own words."

LEGAL.

The United Telephone Company v. Bassano (before Mr. Justice Pearson).—This was a summons in the nature of an interpleader action to determine a question under the apparent possession clause of the existing bankruptcy statutory law though under the accident of circumstances the summons was actually taken out in a patent action. Messrs. Bassano and Slater were manufacturers of telephonic instruments at Webster's Yard, Traffic Street, Derby. They were made defendants to an action by the United Telephone Company. Judgment was given against them, with costs. The costs amounted to £1,200. The plaintiffs got them taxed, and proceeded to enforce payment by levying execution. The chattels of the defendants on their premises were seized by the sheriff in November last. On the day following the defendants presented a petition in bankruptcy, and a receiver in bankruptcy of their estate was appointed. Previously to that Messrs. Bassano and Slater had executed a bill of sale to a Miss Oakes of all their stock-in-trade and plant, and notices of claim were given to the sheriff on behalf of both the receiver in bankruptcy and Miss Oakes. The sheriff took out an interpleader summons to determine which of the three parties, the execution creditors, the receiver in bankruptcy, or the assignee under the bill of sale, were entitled. The United Telephone Company and the receiver impeached Miss Oakes's title on very similar grounds, and the former admitted that if they were right the receiver was entitled before them. So the question lay substantially between Miss Oakes and the general creditors as represented by the receiver. The validity of the assignment to Miss Oakes was disputed because it did not in form comply with all the requisites of the existing statutory law affecting bills of sale, and also as being fraudulent under the Act of Elizabeth. His Lordship held that the assignment was not fraudulent, and acquitted Miss Oakes from any imputation of not having acted *bonâ fide;* but held, on the authority of a number of cases, that the bill of sale was void. But there was a third question—the really substantial question in the case. Miss Oakes asserted that she had a title by reason of her having actually taken possession of the chattels sold to her, and the point was whether, under the circumstances, the goods were, within the meaning of the Bankruptcy Act, in the order and disposition of Messrs. Bassano and Slater at the time the bankruptcy petition was presented. At the date of the bill of sale there was a contemporaneous agreement that Miss Oakes should carry on the business for herself and employ Messrs. Bassano & Slater as servants, paying them each a weekly salary of £2. The key of the premises was given to her, and some articles were taken away by her. A circular was sent to certain creditors intimating that the firm had been changed to Bassano, Slater and Oakes. The business was to some extent carried on after that date. Certain payments were made by an agent of Miss Oakes on behalf of the business, including the weekly salaries of the defendants. Mr. Micklem appeared for the United Telephone Company; Mr. Yate Lee for the receiver; and Mr. Alfred Cock for Miss Oakes. Mr. Justice Pearson, on Saturday, held that the goods were in the apparent possession of the bankrupts at the time of the commencement of the bankruptcy, and belonged to the receiver.

Electric Church Bells.—The special points in connection with the Jensen electric bell system are generally known, but a recent application is to adapt these bells for use in church towers. The gong is of the ordinary church bell pattern, and the coil, armature, and hammer are all contained inside it. The example which has been brought under our notice weighs 60 lbs., and the size of the dome is equivalent to an ordinary hemispherical dome of 22 inches. It is said that with this form of bell the work of the old-established bellringer will be very much lightened, for he could ring a whole peal by alternately pressing the proper keys. The system has been introduced by the Woodhouse and Rawson Electric Supply Company of Great Britain, Limited.

NOTES.

The Electric Light in Stockport.—Some time ago it was mentioned that Mr. T. W. Blackshaw, of the Bridge Street Restaurant, Stockport, had fitted his premises with electric lighting apparatus, but that the driving power then available was insufficient to produce satisfactory results. With a view to giving the system a fair trial, he has had a new horizontal engine put down, capable of giving 12 H.P. with steam indicating 80 lbs. pressure. The boiler and engine were manufactured by Messrs. Marshall, Sons, and Co., Limited, of Gainsborough. The apparatus for lighting was put in by Messrs. G. Durham and Co. The premises are completely furnished throughout with Woodhouse and Rawson incandescent lamps. In a convenient position there are 40 Elwell-Parker accumulators, in which a good supply of electrical energy is stored for use as required; by this arrangement, during summer, when the light is little used, it will probably be necessary to run the engine only once a week in order to re-charge the accumulators.

The Electric Light in the Royal Navy.—Commander Crawford J. M. Conybeare, representing the Admiralty, has made an examination of the torpedo and electric light fittings on board the *Amphion*, 10, cruiser, Staff-Commander Gwynne, at Keyham. The testing of the electric search lights proved a great success, the dockyard and harbour being brilliantly illuminated. Commander Conybeare has also conducted similar trials on board the *Curlew*, gun and torpedo vessel, Lieut. W. H. P. Buckner, with equally satisfactory results.

Electric Lighting in Greenock Harbour.—At the last monthly meeting of the Greenock Harbour Trust, the sub-committee appointed to consider the question of the method of lighting to be adopted at the James Watt Dock submitted their report. It is proposed to light it by the electric light, with seven arc lamps, each of 2000 candle-power, erected on iron four-tubed lamp-posts, 30 feet high, which, with the Brush dynamo and the engine and cables, would cost £786. The cost of maintaining the system was estimated to amount to £150 per annum, whilst the cost of gas would be £100. They agreed, however, to light the sheds and warehouses by gas. The report was adopted, and remitted back to the committee to carry out the arrangements referred to therein.

Ship Lighting. — Last week, a magnificent steel auxiliary steam yacht, named the *Miranda*, was launched from Messrs. Ramage and Ferguson's yard at Leith for Sir George Curtis Lampson, Bart., commodore of the Royal London Yacht Club. Electric lighting by Messrs. Siemens Bros. and Co. is to be used all over the vessel, the number of separate lights being about 60 in all.

Messrs. Henry Bennet and Co., Glasgow, have been entrusted with the electric lighting of the handsome steel paddle steamer *Edinburgh Castle*, just launched. The steamer is intended for pleasure sailing on the Firth of Forth.

The Gulcher System.—The Gulcher Electric Light and Power Company has recently erected for Messrs. Jonas Brook and Brothers, Meltham Mills, Yorkshire, one of the largest installations of incandescent lamps carried out in Yorkshire. The 260 lamps in this installation are of Swan-Edison 90 volt type, and the current is generated by a No. 5 Gulcher compound wound dynamo of the latest and most improved pattern, and capable of giving a current of 220 amperes at 100 volts E.M.F., or an electrical output of 22,000 watts at a speed of 500 revolutions per minute, so that it is large enough to enable the lighting to be extended should Messrs. Brook Bros. so desire. The motive power for driving the dynamo is taken from the main line shaft, which is fitted with a friction pulley; this avoids the inconvenience of fast and loose

pulleys and striking gear, and answers the purpose admirably. The lamps are all suspended from the ceiling by means of long wrought iron pendants, and, in order to obtain the utmost effect from the lamps, each is fitted with an opal reflector 6 in. in diameter. This installation is the third of the Gulcher Company's system which Messrs. Brook Bros. have adopted. The second installation was supplied for lighting their Royde Edge Mills, where a No. 4 compound wound dynamo is used to run six arc lamps in the dye houses and 20 incandescent lamps in the different departments. As this installation will ultimately be extended, the dynamo machine is capable of running 60 more incandescent lamps of 20 C.P. This installation shows the advantage of the Gulcher system of electric lighting for factory work, as it enables arc lamps to be used in dye houses or larger buildings and incandescent lamps in the small rooms or departments, both being driven from one dynamo machine, and, in fact, from the same arrangement of circuits. The system has already been adopted largely in Yorkshire, and the following may be mentioned as the most prominent firms :—Messrs. James Watkinson and Son, Holmfirth ; J. Sykes and Co., Brockholes ; and E. Fox and Sons, Dewsbury.

Taunton and the Electric Light. — At a recent meeting of the Taunton Market Trustees, Mr. A. G. Massingham, who has undertaken the introduction of the Thomson-Houston system of electric light into Taunton, wrote stating that he thought it would be a great misfortune if the centre of the town remained in its present position as regarded lighting. Rather than it should remain in a state of semi-darkness he should be pleased to provide 7 arc lamps of 1,200 candle-power each, and keep them burning until 11 p.m. until Christmas (when the contract of the gas company expires), free of cost, if the trustees would pay the expenses of the electric engineer in fitting up the lamps, &c. The cost for wiring was £80 per mile, which would include fixing the lamps on the posts. The trustees were of opinion that as they were already paying the Town Council for lighting the town with gas, they could not expend any further sum in that direction, but it was resolved to give Mr. Massingham permission to erect the posts and necessary fixtures on the Parade, and also to contribute £10 towards the expenses of fitting (estimated by several members at £20). A hope was expressed that the Town Council would subscribe the other £10.

The Electric Lighting Bills.—A meeting of the Association of Municipal Corporations was held in the Westminster Palace Hotel last week to consider the three electric lighting bills which the House of Lords have sent to a Select Committee. Sir George Morrison (the town clerk of Leeds), explained that at a joint meeting of the Parliamentary and Electric Lighting Committees of Leeds, it was determined to support the Government Bill, which, it will be remembered, practically extends the period of purchase from 21 to 42 years. Sir George Morrison moved that the meeting should accept a similar resolution. This was agreed to with the rider that a clause be added asking the Government to make the consent of a Corporation an essential condition to a provisional order being granted to a company. It was also resolved that the town clerks of Leeds, Nottingham, and Birmingham, and representatives from the corporations of Liverpool, Manchester, Blackburn, and Sheffield be requested to give evidence in support of the resolution of the association before the Lords' Committee.

Lord Ravensworth last week presented a petition to the House of Lords from the Mayor and Corporation of Newcastle-on-Tyne against the Electric Lighting Bills of Lord Rayleigh and Lord Bury, and against certain provisions of the Government Bill on the same subject. Lord Ashford (Viscount Bury) has presented petitions from Messrs. Crompton and others, and the Dynamicable Society, against the Goverment Bill, and praying to be heard by counsel before the Select Committee. The Electric Lighting Act Committee has also drawn up a petition, which is shortly to be presented, against the Government Bill and in support of Lord Rayleigh's Bill, and praying to be heard by counsel.

New Telephones.—Our esteemed American contemporary, the *Electrical World*, to whose columns we are indebted for our description of the new forms of telephonic instruments shown on pp. 343-344, makes the following comments thereon :—"It is well known that with carbon electrodes only two or three cells can be used for telephonic transmission, and any increase in the number results in a loss of efficiency. The reason is, that a heavier current than is represented by that number of cells causes a burning of the carbon as well as a sparking, due to the slight movements of the carbon electrodes. The spark allows of the continuous passage of the current, and prevents the *sudden* variation which is essential to good effect in a telephone receiver. It is evident, then, that the primary current in the carbon transmitter is of necessity limited to a very weak one, and all attempts to increase the number of batteries allowable have failed for the reason above given. If, with platinum contacts, the same percentage of variation in resistance can be obtained as with carbon, a great point has been gained. We may then construct telephone receivers of a more robust nature, so that they will not be influenced by weak currents, and most of the induction troubles will be at an end. In the lack of practical information regarding the efficiency of the platinum contact, it would be injudicious to carry our reflections further. It must be borne in mind that the mere substitution of a heavy current for a weak one in the transmitter is in itself no gain. But if the heavy current can be varied in the same degree as the weak one, then a decided improvement has been made. To substantiate our statements in regard to the use of a more hardy receiver, we would refer to Mr. Bergmann's telephone, illustrated on another page, and in which the currents travel axially through the magnets, no coils being used. Such a receiver would hardly, in our opinion, detect the presence of induction currents, and the ordinary telephone current would probably affect it in but a very small degree. But with a strong current made possible by the new transmitter, such an arrangement might prove highly efficient and serve the object for which it was designed." The *Electrical World* is right ; the requisite telephonic instruments are, a less sensitive receiver than the Bell, and a transmitter which can be made to vary heavier currents.

A Combined Mechanical and Electrical Telephone. —Messrs. G. Durham and Co. have brought out a combination apparatus, which is said to be successful and practical. The following vague description has been sent to us by the above firm : "It consists of a number of 'sound chambers,' one influencing the other to such a degree that by placing a cone shaped funnel of stiff material, such as metal, in front of the transmitting box, the sounds are given out, and every word can be distinctly and clearly heard at a distance of several yards from the instrument. By taking away the cone and placing an ordinary ear piece and flexible tube (as in the Gower Bell) every sound is perfectly private, a whisper being successfully reproduced when the line is not over an unreasonable distance. The electric currents are passed from a switch to the vibrating plates, and through the sound chambers to the distant station. These electrical charges and discharges can be conveyed over a considerable length of line. The line for conveying vibrations can, with careful fixing, be successfully worked over a considerable astonishing distance." They are in operation at the extensive hat works of Messrs. Christy and Co., Stockport.

Telephone Posts and Wires.—The Bournemouth Commissioners at their last meeting passed a draft agreement with the Western Counties and South Wales Telephone Company, permitting the latter to erect posts in several roads under their jurisdiction.

Telephone Charges.—Mr. Chas. Lever, whose pen is ever active, so much so, indeed, that we fear he does not always think calmly over the matters which rouse his ire, has sent a lengthy communication to the Manchester *Guardian*, of April 2nd, on the subject of telephone charges. Prof. Silvanus Thompson's instruments are cited as being without the pale of the Edison-Bell claims, and Mr. Lever concludes, without any grounds for so doing, as follows :—"The fact is that the United Telephone Company cannot and will not attack Prof. Thompson's Valve telephone in the face of the scientific evidence which can be produced as to the non-infringement of the same. Already the telephone monopoly, both in this country and in the United States, is on its last legs. And when this structure of telephone monopoly at last goes reeling and toppling over we shall not be at all sorry, but we shall gladly hail the day that brings us free trade in telephones."

Our views on this monopoly question are too well known to need restating, but we should be blind indeed, even to the extent of groping in the darkness which surrounds Mr. Lever, if we went so far as to say that the U. T. Company cannot and will not attack the Valve telephone. With the judgments of Lord MacLaren and of Justices Fry and North in their favour, why should the company fear the issue of a legal contest with the owners of Prof. Thompson's instruments? Is not the case supporting the Valve transmitter, the tube leading to it, in short the entire combination, in the light of their judgment, a diaphragm? Mr. Lever, ourselves, and others who would gladly hail free trade in telephony, might write till doomsday, but with what object, when our legal luminaries uphold the monopoly?

Electricity on Board a New Japanese Cruiser.—There arrived in Plymouth Sound last week the *Naniwa Kan*, a newly-constructed cruiser of the most modern type, built on the Tyne for the Japanese Government. The two engine rooms, which are so constructed that during an action or in case of any emergency they can be made watertight, are beautifully illuminated with Swan incandescent electric lights, and the coal bunks, stokeholes, and captain's saloon are similarly lighted. On the bridge of the vessel there is a circular conning tower, from which the captain can himself steer the ship by electricity. At either end of the bridge are two electric search lights of great power and brilliancy, and about midway between these are a steering apparatus for the officer on watch, and an engine room telegraph. Forward and aft on each broadside are torpedo projecting stations. An electric battery is employed to fire the torpedo at the right moment. This vessel has cost nearly half a million of money.

The Edinburgh Exhibition.—It has now been decided to lay down the electric tramway between the east and west gates on the north side of the grounds—a distance of fully a quarter of a mile. The line will be single, and the cars will make trips backwards and forwards on it. The committee met on Saturday to consider whether they will let out the railway on contract or manage it themselves.

On Monday night an experiment was made with the Thomson-Houston electric light system, in the presence of the Lord Dean of Guild Gowans, chairman of the executive; Mr. Carey, C.E., engineer for the exhibition; Mr. W. A. Bryson, electrician; and Mr. Ellis, representative for Messrs. Robey & Co. It is only about a fortnight since Messrs. Robey & Co.'s engines were placed in position, and last week the dynamo-electric machines in connection with these engines were received from America. The result of the experiment was regarded as highly satisfactory, and the trial was made with the view of carrying on the work at night if necessary. Electricians may feel interested in the statement that these dynamos were received in pieces from the factory in America, and have been fitted together without any preliminary testing.

The Valve Telephone.—Messrs. George Durham and Co. have fitted up a communication by telephone for Mr. Blackshaw, of Stockport, between his residence and restaurant, a distance of 1½ miles. The apparatus is said to work very satisfactorily, the speaking being clear and loud. The firm has also fitted a set for Mr, Brook, of the same place, who gives his opinion greatly in their favour.

Electric Locomotion Wanted.—On Monday last a steam engine and car belonging to the Birmingham and Midland Tramway Company was travelling down Cape Hill, Birmingham, when one of the steampipes burst, hurling the driver off the foot plate. The engine ran down the hill for some 100 to 150 yards when it ran off at a siding and went over on its side. The car, with a full complement of passengers, luckily kept the rails. The driver was badly scalded about the face and neck.

The Leith Flour Mill Explosion.—Writing to the *Scotsman*, Mr. Charles Lever says :—"The disastrous explosion in a flour mill at Leith, caused by the accidental ignition of the exhaust flour, which is highly inflammable, shows how important it is that all such mills should be lighted by means of electric incandescent lamps. The flour floating about in a corn mill is as liable to cause an explosion as the fluff in a cotton or woollen mill, or the small impalpable dust of a coal mine. There can be no security with gas, oil lamps, or candles in use where inflammable dust is floating about. Many of the flour mills in this country are already lighted by electric glow lamps, the incandescent filaments of which burn in a vacuum. When such a method of lighting is fully appreciated and generally adopted, explosions in flour mills and coal mines, and fires in factories and warehouses, will be less frequent."

Royal Institution of Great Britain.—Amongst the probable arrangements for the Friday evening meetings after Easter a paper is announced for Friday, May 28th, by Prof. Oliver Lodge, D.Sc., on "Electrical Deposition of Dust and Smoke."

Self-Induction Experiments.—The experiments of Mr. Willoughby Smith are, we consider, no proof whatever of the incorrectness of Prof. Hughes conclusions. The results arrived at are just what might be expected when a *galvanometer* is used. When a rapid series of reversals or feeble induction currents of very short duration are sent through a galvanometer, no motion of the needle is observed, because the rate at which the impulses take place is far greater than the rate at which the needle of the instrument can vibrate; but place a telephone in the circuit, and the action taking place becomes evident at once. If an *electro-dynamometer* be substituted in the place of the galvanometer, the effect of the continual impulses, even if they be reversals, becomes evident by a permanent deflection, since the influence of the currents is always to cause the coil of the instrument to turn in one direction. The figure of merit, however, of the best form of electro-dynamometer is comparatively small, and unless the inductive effects dealt with are very considerable, they would hardly be appreciable on such an instrument; the telephone, in fact, is at present the only instrument which will enable researches with feeble inductive currents, such as those dealt with by Prof. Hughes, to be examined.

Another Warning.—We are asked to warn the electrical public against a man who has been imposing on several firms of late. His method is to pretend having means of influencing electrical contracts of various kinds, which are purely imaginary. He then extracts money on various pretexts, with which he generally gets drunk. He is a small, stoutish, middle-aged man, with red face, sandy hair and whiskers, and prominent eyes.

The Silvertown Company.—On account of the loss this company has sustained through the death of Mr. Henderson, the late chairman, the following changes in the Board of Directors were made at the last extraordinary general meeting of the company:—Mr. Matthew Gray, the general manager, has joined the Board as managing director, and Mr. S. W. Silver has become chairman of the company. Mr. Robert Henderson, nephew of the late chairman, and son of the late Mr. Robert Henderson, who, with Mr. S. W. Silver, was one of the originators of the Silvertown Company, has accepted a seat on the Board. His position in the City of London should render him a valuable addition to the Board. Mr. George Henderson, son of the late chairman, has accepted the trusteeship for the debenture holders.

Lightning Conductors.—Four tall chimneys and three oil tanks at the Philipstown Oil Works, Linlithgow, have just been fitted with lightning protectors. Two of the chimneys (160 feet high) have each two copper tape conductors 1 inch by $\frac{1}{8}$ inch, terminating in a copper cone-shaped rod with four points. The other two chimneys (120 feet high) have strand conductors of 49 wires with a diameter of $\frac{3}{8}$ inch. The oil tanks have each a cable conductor made up of 49 wires and having a diameter of $\frac{1}{2}$ inch. The whole of the metal work on the buildings to which the chimneys belong are connected to the main earthing wire by means of screw couplings and solder. The same firm (Messrs. Post & Son, Greenock) has also protected the tower of Birkwood Mansion House (100 feet high), which was damaged some time ago by lightning, by means of a tape conductor $1\frac{3}{4}$ inches by $\frac{1}{8}$ inch, and terminated by a copper rod with four points carried 10 feet above the stone work. All connections are made by screw couplings.

Quality of Iron in Dynamos.—It is well known, says the *Mechanical World*, what an influence the quality of the iron in the field magnets has upon the ultimate output in a dynamo, and a case in point is mentioned by Mr. Gisbert Kapp, showing how impossible it is to foretell accurately the performance of a dynamo unless the quality of the iron be exactly the same in the manufactured machine as the sample submitted. In the case of two machines manufactured for him there was a difference of electromotive force of 20 per cent. between the two, although the machines were of exactly the same dimensions and treated in the same manner. It was imagined that in the first machine the iron magnets had not been sufficiently annealed in consequence of the shortness of time allowed for the work. A second pair of field magnets were ordered and an extra time allowed for the work, the consequence being that 20 per cent. more electromotive force was obtained.

Resistance of Cast and of Pure Iron.—In making some experiments as to whether there was any connection between the magnetic properties and the electric conductivity of iron, Dr. John Hopkinson was unable to find any, but one interesting result came out, that the electric resistance of the samples of cast iron which he tried was 10 times as great as the electric resistance of pure iron. This result has certain important applications to dynamo machines.

The Heating and Cooling of Insulated Conductors.—Prof. W. A. Anthony, writing to an American contemporary, says:—"In an article in the February *Electrician and Electrical Engineer*, Carl Hering, in speaking of 'some calculations or statements made, that insulated wire will cool more rapidly than naked,' seems to imply a doubt whether such is the fact. A mathematical investigation does show that, under certain conditions, insulated wires will cool more rapidly than naked, and to determine whether these conditions obtain for the insulated wires used in practice, a series of experiments were made last spring and summer at the physical laboratory of the Cornell University, upon nearly all the styles of insulated wire in common use. The experiments were conducted by Mr. J. G. White, who made the matter the subject of a thesis for the degree of doctor, and, as the whole investigation will shortly be published, only the general methods of experiment and the results will be given here. Wires in lengths of about 100 feet, half covered and half naked, of various sizes and styles of insulation, were obtained from the manufacturers. One of these wires being strung up in such a way that the covered and naked portions were equally exposed, a current, increasing in strength from one whose heating effect was inappreciable, to the largest the wire would bear, was sent through the entire length of it, and the resistances of the two portions measured while the current was passing. To provide for the measurement of the resistances the wire was made to form one branch of a Wheatstone's balance, the other branches of which were so arranged as not to be heated by the currents that flowed through them. In *every case* the resistance of the naked wire increased much more rapidly than that of the covered, and, in general, the thicker the insulation, the less the increase in resistance. In the case of a 'Clark's' insulation, for instance, where the wire was 65 mils, and the covering 285 mils in diameter, the increase in resistance due to heating by the current, was, I think, about three times as much for the naked as for the covered portion. I was myself surprised to find that the effect of the covering to keep the wire cool, was the general, and not the exceptional effect. In what respect a covered wire differs from a covered steam pipe, will appear when the complete account of this investigation is published."

An Ancient Electric Locomotive.—Professor Page made a trial trip with his electro-magnetic locomotive on Tuesday, April 29, 1851, starting from Washington. The progress of the locomotive was at first so slow that a boy was enabled to keep pace with it for several hundred feet. But the speed was soon increased, and Bladensburg, a distance of, I believe, about five miles and a quarter, was reached in thirty-nine minutes. When within two miles of that place, the power of the battery being fully up, the locomotive began to run, on nearly a level, at the rate of nineteen miles an hour. This velocity was continued for a mile, when one of the cells cracked entirely open, which caused the acids to intermix, and as a consequence, the propelling power was partially weakened. Two of the other cells subsequently met with a similar disaster. Seven halts were made, occupying in all forty minutes. But, notwithstanding these hindrances and delays, the trip to and from Bladensburg was accomplished in one minute less than two hours. The great point established was, that a locomotive on the principle of Professor Page could be made to travel nineteen miles an hour. But it was found on subsequent trials that the least jolt, such as that caused by the end of a rail a little above the level, throw the batteries out of working order, and the result was a halt. This defect could not be overcome, and Professor Page reluctantly abandoned his discovery.—*Ben. Perley Poore, in the Boston Budget.*

Society of Arts Lectures.—Prof. George Forbes is delivering a series of elementary lectures on "Electricity" at the Society of Arts on Saturday afternoons. The first and second have been given, the subjects being "Electromotive Force and Potential," and "Currents and Resistances." Others will be: May 1st, "Magnetism;" May 8th, "Electro-magnetic Phenomena;" May 15th, "Induction;" and May 22nd, "Electrical Measurement."

Sale of Electrical Plant.—Intending purchasers of electrical plant will doubtless find an excellent opportunity by attending the sale of the effects of the British Electric Light Company, which will be conducted by Messrs. Wheatley Kirk, Price, and Goulty, at Turk's Head Yard, Turnmill Street, E.C., next Tuesday.

Colonial and Indian Exhibition.—A meeting of the Reception Committee was held on Monday, at the Society of Arts. The Committee considered a report from the sub-committee as to the arrangements which could be made for excursions for Colonial and Indian visitors. Mr. Somers Vine, the Official Agent of the Exhibition, attended, and reported to the committee the arrangements which had been made with the railway companies with the view of affording extended facilities for railway travelling to all Colonial and Indian visitors coming to the Exhibition. The chairman reported that, in accordance with the wishes of the committee, and with the approval of H.R.H. the Prince of Wales, he had communicated with the mayors of some of the chief provincial cities, asking if they would arrange for visits of parties of distinguished visitors. It was resolved that a subscription list should be opened; and the hope was expressed that those who have enjoyed the benefit of Colonial hospitality will avail themselves of this opportunity of contributing to the entertainment of those who come to England, from the Colonies and from India, for the purpose of visiting the Exhibition.

The first meeting of the Conference Committee appointed by H.R.H. the Prince of Wales, the Executive President of the Royal Commission, was held on Tuesday, the 13th inst., at the Society of Arts. The committee considered the question of conferences and lectures at the Exhibition, and appointed a small subcommittee to prepare a scheme. The committee propose to arrange for a series of lectures or papers on the different classes of products illustrated in the Exhibition, and they hope to be able to secure the assistance of qualified experts to deal with such subjects as food resources, timber supply, agricultural resources, textile fibres, &c. It is also proposed to arrange for the reading of papers on the resources of the Colonies individually.

Non-Inflammable Leads.—The Liverpool Telephonic Exchange, of the Lancashire and Cheshire Telephonic Company, was again opened for business on Monday last, and, considering the amount of damage done to the wires and instruments, which were almost completely destroyed by the alarming fire of the previous Wednesday, great activity and energy must have been exercised to have got the place in working order again. Many miles of wire were required to replace the insulated wires, which, from their insulation (gutta percha), were easily destroyed, and, it may be remarked, perhaps fed the flames. However, there was an extraordinary exception which is specially deserving of remark. The Lancashire and Cheshire Company had ordered some lengths of 100-wire telephone cables which was specified to be *non-inflammable*, and a short time before the fire, Messrs. W. T. Glover & Co., of Manchester, supplied them with two lengths of 100 wire gutta percha insulated cables, protected by their patent "non-ignitable" process. From the test room to the switch room numerous gutta percha wires were carried in a wooden troughing, and in this was also placed two portions of the 100-wire non-ignitable cable. The fire broke out in the test room and extended to the switch room, and the troughing was in flames and the contents exposed to intense heat. On examination after the fire had been subdued it was found that the contents of the troughing were completely destroyed with the exception of the "non-ignitable" cables, which proved to have thoroughly resisted the intense heat, and deservedly earned their name. Ordinary telephone cables, from the nature of the insulation and the wrapping, are considered dangerous, as being liable to carry fire from one point to another; but this form of cable has been successfully manufactured to overcome this dangerous fault.

The Varley Patents Proprietory.—We are requested to make known that Mr. S. A. Varley is not in any way connected with the above-mentioned firm.

The Gas Companies and the Electric Light.—At the recent meeting of the Commercial Gas Company, the subject of the electric light came under discussion, one shareholder admitting that the light was "making steady progress, not noisy, but sure." It had, hitherto, stimulated the demand for gas. Another shareholder was sure the gas companies would always be able to undersell the electric light. Mr. Jones, the engineer of the company, also spoke of the cost of electric lighting, and said that the Electric Lighting Exhibition had given a stimulus to the invention of gas burners, with the result that they were now in possession of burners which bid fair to rival the electric light in brilliancy and to surpass it in economy.

The Dissipation of Heat in Wires.—The remarks of Professor Anthony on the heating and cooling of insulated conductors are interesting, but it makes one sad to see the uncertainty still existing upon this subject, and once again we desire to assert that the late Robert Sabine, some years ago, showed most conclusively in these pages, all the effects which have so surprised Professor Anthony.

The Albert Palace Lighting.—Which will be the favoured company for supplying the Albert Palace, Battersea, with steam power and dynamos, together with thirty arc and 3,000 incandescent lamps, for a season lasting four months? We fancy the "People's Caterer" has a sneaking regard for a system which has already served him well.

Communication with Moving Trains.—We shall hope next week to give an illustrated description of the Edison system of telegraphic communication with moving trains. It seems more than probable that the Phelps method which we published some time since anticipates in all respects that of Mr. Edison. Considerable interest is manifested in the States in this revived idea of inductional telegraphy.

Burglar Alarms.—Thieves for the second time within twelve months visited the premises of Mr. Horton, ivory cutter, of Sheffield, the other day; but since the last occasion, Mr. Horton has called in the aid of an electric alarm, with the result that two burglars who this time effected an entrance, caused the electric bell to ring, thus ensuring their capture, which, however, was not accomplished until a terrific struggle had taken place between one of them and a policeman.

Telegrams Insufficiently Addressed.—Lord Wolverton the Postmaster-General, replying to a memorial from Bristol in reference to the requirement recently made for the registration of addresses, says that in consequence of the enormous increase which has taken place since the new rate for telegrams was introduced in the number of telegrams which have been insufficiently addressed, it has been found necessary to discontinue the practice formerly adopted of referring to directories in order to supplement these insufficient addresses. At the same time, the Postmaster-General feels that some distinction ought to be made between cases in which the addresses of telegrams have been intentionally curtailed so as to save expense, and cases in which any vagueness of the address has not been intentional, and he has accordingly given directions that when the sender has evidently done his best to give a full address, a relaxation of the rule is, as far as possible, to be permitted. With regard to a statement in the memorial, to the effect that the action of the department would seem to indicate a desire to compel the public to pay fees for the registration of abbreviated addresses, it is far from Lord Wolverton's wish that the registered abbreviated address system should be extended, and he would much prefer that full addresses should be given.

Are Secondary Generators Reliable? — We are given to understand that the Gaulard-Gibbs transformers used in the Grosvenor Gallery installation give results anything but satisfactory, and that they are to be replaced by a new type of apparatus designed by Mr. Ferranti, who is now engaged in the endeavour to save this installation from meeting with an untimely end. Mr. Ferranti's transformers will be used in parallel, we believe, after the manner of the Zipernowsky-Déri apparatus, and not in series as employed by Gaulard and Gibbs. Perhaps this projected change explains why it has been such a difficult matter to learn anything definite respecting the working of the Grosvenor Gallery lighting plant.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Manchester and District Edison Electric Light Company, Limited.—The registered office of this company is now situate at 12, Victoria Buildings, Manchester.

Edwin Fox and Co., Limited.—The annual return of this company, made up to the 25th ult., was filed on the 2nd inst. The nominal capital is £50,000 in £10 shares; 3,000 shares are allotted, upon 2,611 of these the full amount has been called, and £5 per share upon the remaining 389 shares. The calls paid amount to £27,750, leaving £305 unpaid.

Elwell-Parker, Limited.—The annual return of this company, made up to the 8th inst., was filed on the 15th inst. The nominal capital is £50,000 in £10 shares; 1,600 shares have been taken up, upon 850 the full amount has been called and paid, and £8 per share upon the remaining 750 shares. The calls paid amount to £14,500.

Telephone Company of Egypt, Limited. — The annual return of this company, made up to the 30th ult., was filed on the 6th inst. The nominal capital is £100,000 divided into 16,000 preference and 4,000 deferred shares of £5 each; 12,071 preferred and 4,000 deferred shares have been taken up. The calls paid amount to £355; the sum of £80,000 being considered as paid upon 12,000 preferred and 4,000 deferred shares.

CITY NOTES, REPORTS, MEETINGS, &c.

Eastern Extension, Australasia and China Telegraph Company, Limited.

THE twenty-fifth ordinary general meeting of this company was held at the Cannon Street Hotel on Wednesday, under the presidency of Mr. John Pender.

Mr. F. E. Hesse, the secretary, having read the notice convening the meeting,

The Chairman stated that the gross receipts for the half year amounted to £247,017, a decrease of £1,070 as compared with the corresponding half of the previous year. During the first part of the half year the receipts compared very favourably with the corresponding period, but in November they began to fall off, and there had been a large monthly decrease since. The Egyptian campaign, the expedition up the Nile, and more recently the Afghan frontier dispute, had caused a great deal of telegraphing, which had saved them from feeling the effects of the long-continued badness of trade, but now that nothing of absorbing interest was transpiring in the East their receipts suffered from the prevailing depression. But trade, although it might languish for a time, never died, and with the revival of trade he expected to see increased receipts. Enquiry had been made with respect to the reserve fund, which now stood at £565,644, and he might say that the policy they were pursuing was, as far as possible, to make the property a sound and permanent investment. They could not have a large dividend and at the same time an increase in the value of their property; but by forming a large reserve fund they placed their company in a strong position; they got a moderate, and, he hoped, a satisfactory dividend; and, at the same time, their property was increasing in value every six months. The directors wished to maintain the company in that position because, as he should have occasion to tell them later, there was threatened opposition, and they could meet that opposition better if they had a good round sum in their exchequer than without it. They were yet in ignorance as to the life of a cable. Twenty years, thirty, and even more, had been suggested; but they had, in their own system, to renew a cable which had only been down for twelve years; this showed the uncertainty of this class of property, and, until they knew more about it, it would be infinitely better for all concerned to go on adding to the reserve fund. A total of £36,076 had practically been expended during the half-year in renewing certain sections of the system. Negociations had been going on for some time with the Australian colonies with regard to the reduction of tariffs, and the company had decided to make a substantial reduction in the rate to Australia and China, to take effect from July 1st. For Australia they were going to reduce from 10s. 8d. to 9s. 4d. per word, and for China from 8s. 4d. to 7s. 1d. They had hoped that the negociations with the Indian Government would have resulted in the lowering of the high transit rate, so that a reduction of 2s. per word to Australia might have been brought about, but their efforts had been unsuccessful. The Indian Government seemed, however, inclined to re-open negociations, and possibly a better arrangement might be made with respect to the traffic across India. They had offered the Australian colonies a further reduction of 1s. 4d. per word provided they would extend the period of the subsidy of £32,000 which they now enjoyed, so that it might run twenty years from the present time instead of only fourteen. New South Wales, South Australia and Western Australia, were prepared to agree to that arrangement; Victoria was as yet in doubt, but Queensland and New Zealand refused to agree because in their opinion the rate ought only to be a fraction of the present charge, and they would do nothing that would tend to discourage the establishment of an opposing system. They had been blamed for not giving the Colonies the whole reduction without any reference to their income; of course, it was very well to ask for those benefits, but there were always two sides to a bargain, and he hoped that any bargain the directors might make would be made in the interests of the shareholders and also of the telegraphing public. The reductions contemplated would cause an immediate loss of £62,000, and against that, if the extension of the subsidy took place, they would have £32,000 a year for six years, and during that six years he hoped the growth of telegraphy would bring them to about the same point they now occupied. Judging from statements that had appeared in the newspapers it would seem that efforts were being made, by persons who wished the public to believe that they were officially representing the Colonial Governments in this matter, for establishing a second cable to Australia. The routes advocated were: (1) From Queensland to Ceylon, touching at Java or Timor, a length of about 4,500 knots, costing about £787,000; (2) Western Australia to Europe, *viâ* the Mauritius, South Africa and West Coast, a length of about 14,600 knots, costing over £2,500,000; and (3) Brisbane to San Francisco, Vancouver's Island—touching at Honolulu—Feejee and New Caledonia, a length of about 8,000 knots, costing over £1,500,000. The third route seemed to be preferred, but both the Mauritius and Pacific routes presented exceptional difficulties in the way of enormous depths, long stretches of cables, and eventual costly repairs, while, regarding the financial aspect, it did not promise a sufficient return to cover working expenses and amortisation at a 5s. tariff, unless the Colonies were prepared to subsidise the project. These opposition schemes, he believed, were intended to benefit the promoters quite as much as the Colonies, and those promoters who had met with disappointment were showing a great deal of animus. A short time ago, during his absence abroad, a concession by the Government of a cable to the West Coast of Africa came before the House of Commons for approval, a concession which had occupied quite two years to negociate, the negociations having been conducted with a Liberal, then a Conservative, and again a Liberal Government. Perhaps no bargain was ever more carefully considered in the interests of a Government than this particular concession; nevertheless, the Government and himself (Mr. Pender) were taxed with dishonesty in the transaction. Both the Liberal and Conservative members of the Governments, however, so completely answered the insinuations, that nothing was left for him to say about the impotent and abortive attack, except this, that one of the speakers let the cat out of the bag when he said that if the concession were approved, then a proposal which he had in view for connecting Australia by the West Coast of Africa could not be adopted. This proposal was for the cable he had just referred to, which would require to be 14,600 knots in length. The saving to Queensland, if that colony would join in the arrangement proposed, would be about £900, and New Zealand would benefit to the extent of nearly £5,000. It was a mere sentiment which kept them back, the idea that by joining the combination they would be building up a great monopoly, whereas by bringing in another company they would create a competition that must eventually benefit the colonies. Submarine cables formed a class of property, he thought, which should be exempt from competition. The present cables could carry four times the traffic the colonies required of them, and the result of subsidising another system would be that neither would pay. The colonies which paid the larger proportion of the subsidy, however, were willing to support this company, and he had no fear whatever of the future. Their concession from the New Zealand Government expired a short time ago. They had a subsidy of £7,500 from that Government, and renewal of this was now refused. The directors had shown their forbearance by not raising the tariff so far; but they had given the Government notice that on July 1st they would have to deal with the matter.

He (the chairman) was hopeful that before that time the New Zealand Government would have arrived at a decision which would do away with the necessity of any advance in the rate. He moved the adoption of the report and accounts, and the payment of a dividend of 2s. 6d. per share and a bonus of 2s. per share, free of income tax, making, with the previous distributions, a total payment of 7 per cent. for the year 1885.

Lord Monck seconded the resolution, which was carried unanimously.

Lord Monck and Sir William McArthur, were re-elected directors, and the auditors, Mr. Henry Dever and Messrs. Quilter, Ball and Co., were reappointed, the meeting thereupon terminating.

The West African Telegraph Company, Limited.

THE prospectus of this company states that the company is formed to connect the West Coast of Africa by telegraph with Europe, under beneficial concessions from the Portuguese and French governments, by means of cables which will touch at the principal places on that coast and be connected with the existing lines of the Spanish National Submarine Telegraph Company, Limited, to the Canary Islands and Cadiz; and with those communicating with the cables of the Brazilian Submarine Telegraph Company, Limited, at the Cape Verd Islands to Lisbon. This company will thus have alternative routes for its traffic with Europe.

The following are the intended stations of the company:—Cables laid and working: Senegal, French; Bolamo, Portuguese; Bissao, Portuguese; Conakry, French. Cables to be laid: Grand Bassam, French; Porto Novo, French; Principe, Portuguese; St. Thomé, Portuguese; Gaboon, French; St. Paul de Loanda, Portuguese.

The length of the cables which will be required to provide a service for the above stations is about 3,600 nautical miles, to be laid for the most part in water of moderate depth; they can therefore be easily repaired if interrupted.

The India Rubber, Gutta Percha, and Telegraph Works Company has transferred to this company the Portuguese concession, and has contracted to manufacture, lay, and deliver the cables (including those already laid), and to equip the stations, for the sum of £500,000.

It is expected that arrangements will be completed by which the cables will be landed and stations opened at the British settlements of Bathurst, Sierra Leone, and Accra, and in connection with which a portion of the Portuguese concession relating to the establishment of telegraphic communication between the Cape Verd Archipelago and the main land (but in no way affecting the guarantee of traffic subsequently referred to) will be disposed of.

The issue of £250,000 share capital will suffice for the present requirements of the company. It is the intention of the directors to issue £300,000 in six per cent. debentures as the work proceeds.

The following will be the sources of the company's income:—

	Per annum.
Portuguese Government 25 years' guarantee of traffic whilst the cables are working, equivalent at the rates stated in the concession to	£42,000
French Government 23 years' subsidy	12,000
Estimated traffic from British and French stations not covered by above guarantee	24,000
	78,000
Deduct working expenses, including transit charges under working arrangements ... £20,000	
Repair and renewal fund 15,000	
	35,000
Balance	£43,000

or more than sufficient for interest and sinking fund on the £300,000 debentures, and for 7½ per cent. dividend on £250,000 share capital.

The Portuguese Government is entitled to have one-half of the income from the Portuguese stations beyond the amount guaranteed applied in repayment of the sums it may have advanced for the guarantee with interest.

The French subsidy is 75,000 fr., say £3,000, per annum for each of the stations at Conakry, Grand Bassam, Porto Novo, and Gaboon, when placed in connection with Europe, diminishing for any station after its traffic receipts exceed £5,000 per annum, and ceasing when they reach £8,000 per annum. No reduction is made for interruptions of traffic on any section not lasting more than ninety days.

Negotiations are in progress for a further grant of £7,500 a year from the Portuguese Government (guarantee of traffic), and for a subsidy of £2,500 a year from the Belgian Congo State, for stations at their respective settlements near the mouth of the river Congo. The establishment of a station at Ajuda, Portuguese Dahomey, with a subsidy of £1,500 a year, is also under consideration. If these negotiations prove successful, then, deducting £3,500 a year for the expenses of working the three new stations, and interest on capital expenditure for the extensions to them, there would be a net revenue of £8,000 a year beyond the existing guarantees and subsidy.

The value attached by the Portuguese and French governments to their West African possessions is shown by the amounts of their guarantees and sudsidies, while there is every likelihood that other European Governments possessing colonies in the same quarter will before long offer similar inducements in order to have the advantages of cable communication extended to them.

But apart from this there can be no doubt that the activity which has recently been displayed in colonising the West Coast of Africa, and the enterprise which is being exhibited in opening up this hitherto neglected portion of the globe, will speedily lead to a great development of trade. The undeveloped resources of the different regions tapped by this cable hold out the certainty of a growing traffic, ensuring in time a good income over and above the substantial guarantees and subsidies already referred to.

The West Coast of America Telegraph Company, Limited.—We are informed that Mr. Alfred Marshall, formerly partner in the firm of Messrs. F. Huth, Grüning & Co., of Valparaiso and Lima, has been elected chairman of this company in place of the late Mr. Robinson Kendal.

TRAFFIC RECEIPTS.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 31st March are £3,067, as compared with £4,010 in the corresponding period of 1885. The December receipts, estimated at £4,455, realised £4,557.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 9th were £2,369, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

AN ordinary general meeting of this society was held on Thursday, April 8th, Prof. HUGHES, F.R.S., President, in the chair. The minutes of the last ordinary general meeting having been read and confirmed, and the list of new and proposed new members announced, the adjourned discussion on Mr. A. Bernstein's paper on "Electric Lighting by means of Low Resistance Glow Lamps" was continued.

Mr. BERNSTEIN commenced by stating that owing to references to the Thomson-Houston system of electric lighting in the discussion he had arranged for a temporary installation of the same on the present occasion, and a number of arc lights would be shown in operation in connection with an improvised chandelier of his own lamps which would be kept working during the evening.

Mr. WHARTON said that in compliance with Mr. Bernstein's request he had fitted up the temporary installation of the Thomson-Houston system referred to; he was the more ready to do this since several mis-statements had been made at the last meeting with reference to the working of the same. The machine at work was an 18-lighter. With the Thomson machine no compensating resistances were required in the lamps when the latter were extinguished. Incandescence and arc lamps were run on the same circuit; such an installation had recently been put up in a West of England town, and no trouble had occurred.

Dr. FLEMING added his protest against the use of the word "strain" in Mr. Bernstein's paper; one word should not be used to signify two different things. A definite meaning for the word "strain" had been given by Prof. Tait. The word "force" was also very loosely used. The expression "electric strain" had been used by Clerk MAXWELL as expressing electrical displacement. Rankine also used the word in the sense of displacement. As regards the qualities of carbons, he would point out that it was well known that heat was more freely radiated from a dead black than from a greyish surface, consequently black, sooty carbon, ought to be better than a grey variety for high efficiency; the fact that the grey carbon was the best for filaments could not, therefore, be due to its colour, but because it was the more refractory variety. He considered the expansion arrangement in Mr. Bernstein's lamp to be a very good one. He could not agree that the finer the filament the more likely it was to have a bad flaw in it. Homogeneity was the important point to be aimed at. The disintegrating effect in filaments he thought was purely a thermal and not an electrical one. The blue glow noticed in lamps was not, he considered, due to the presence of carbonic oxide, it was more probably a phosphorescent effect. He might mention that he had at present in his laboratory an incandescent lamp with a resistance of 900 ohms which took a current of ·1 ampère; this showed how fine it was possible to make filaments; such a fineness would have been deemed impracticable a short time ago. The dangers of the series system were, he believed, about equal to those of the parallel system. The chief difficulty in the former was the insulation of the mains. In America, where the series system was largely adopted, no difficulty was found to exist, as the wires were all aerial ones. Weston lamps were worked on the Philadelphia Railway Station in series with perfect success.

Mr. MORDEY drew attention to the fact that at Brighton, East-

bourne, and other places, installations of glow lamps had been carried out, and were being successfully conducted on the series system. The lamps used, he believed, were usually of ordinary construction arranged in multiple series, but he understood that, although lamps of such low resistance as Mr. Bernstein had been successful in constructing had not been used, some lamps of comparatively low resistance, made by Mr. Swinburne, had been tried, and he believed with success. These lamps took 3·3 ampères, and were of small candle-power. Groups of three of them were inserted in the circuits of the Brush dynamos. Mr. Wright, of Brighton, Mr. Sayers, who carried out the work at Eastbourne, and Mr. Swinburne were present, and he hoped they would give some account of their experience. He thought the author unnecessarily confined himself to a recommendation of lamps arranged in single series. While these would be useful where it was desired to turn lamps on or off singly, it would often be convenient to use groups of lamps in multiple series. He shared the common belief that it was of the utmost importance that lamps should have long lives. He held this opinion in spite of Mr. Preece's statement that it would be better to work lamps at a higher efficiency and with a shorter life than was usual, and also in spite of Prof. Ayrton's remark that the cost of lamp renewals was a very small item in the total expenses. Cost was not the only consideration. There were serious objections to short-lived lamps, as, for instance, the inconvenience and danger of a room or a railway carriage being placed in sudden darkness. If lamps of high efficiency were used he thought it would be an absolute necessity to provide duplicate lamps or filaments, which would be automatically thrown into circuit in the event of breakage. Although in favour of series working, he pointed out that this system must of necessity give a shorter life of lamps than the parallel system, because in the latter, when lamps became old, the increase in their resistance enabled them to exercise a considerable preservative power—they then took less current—while in the series system, as they were always traversed by the same current, disintegration took place with continually increasing effect, and they approached their death very quickly, and not with diminished candle-power, as was the case with parallel lamps. He supported the author's assumption of the possibility of maintaining the current constant. Constant current was a physical possibility; constant difference of potential in any distribution system was not. Mr. Drake had stated that it was difficult to keep the current constant, and that the Brush regulator for this purpose would not act, but he believed that Mr. Sayers had been quite successful in using this apparatus at Eastbourne, even for glow lamps, and he knew that it could be relied on. He could never understand the position taken by those who so strongly opposed high tension working, the advantages of which were enormous. Mr. Bernstein had done a great service in drawing attention at this time to this question, when, thanks to the teachings of Prof. Forbes and others, electrical engineers were in a position to consider such questions on their merits. He thought the constant-current method had been too much neglected, although he did not suppose that in ships and generally in compact installations it would ever be used, as even in the cost of conductors it would offer little or no advantage, a comparatively heavy wire having to be taken to each lamp, but for long lines the reverse was the case. He thought the author would find that a No. 6 wire was needlessly large for true economy in most cases, but it would be interesting to see what could be done with such a wire. With 10 ampères passing through it, the density of current was only 300 ampères per square inch. The loss would be 14 volts per mile, or equivalent to 2·3 60-watt lamps. This was only a loss equal to a 60-watt lamp for every 750 yards. He thought dynamos giving 3,000 volts could easily be used. The largest Brush dynamo gave nearly that E.M.F., and worked quite well. Such a machine would send 10 ampères through 215 miles of No. 6 wire. For every 750 yards taken off, a 60-watt lamp could be put in. Thus on a circuit of 20 miles 450 lamps could be used, and even with this long line the conductor efficiency would be 90 per cent. He might put it in another way as an illustration, and say that an arc lamp in a lighthouse 210 miles from shore could be worked by such a machine if a cable could be laid with sufficiently good insulation, using an earth return. He thought the objection to high tension on account of the danger was not well grounded—the danger was exaggerated. Although for four or five years he had been engaged daily in working with high-tension dynamos in the works of the Brush Corporation, there had never been a case of personal injury or any accident from an electrical machine, although in the same works there had been several accidents from non-electrical machinery. If the opponents of high tension applied their extreme caution to other things, and carried their case, railways would disappear, and cabs and omnibuses would become a thing of the past, the world would sink to a state of almost absolute zero, when there would be very little motion, and that motion very slow. With regard to automatic cut-outs, he thought electro-magnetic ones were best. Prof. Forbes and others had objected to them on account of the energy absorbed. This was simply a question of construction; the energy required could be reduced to almost any extent. In the cut-out of the Brush lamp, for instance, the energy absorbed was only five-eighths of a watt.

Mr. SWAN thought that Mr. Bernstein had fairly stated the difficulties of the series system, and had fairly grappled with them. He considered that the current in lamps might be decreased with advantage, and the electromotive force increased; less loss would then result. The difficulties of insulation were great, but if these were removed, the other difficulties would easily be got over. Both economy and safety are necessary in cut-outs, and the general appearance of these cut-outs must not be over-looked, as it would not do to have them unsightly.

Mr. WRIGHT mentioned that the high-tension system was in full operation at Brighton, and the maintenance of a constant current was carried out perfectly successfully. No accident had arisen from the use of a high-tension current. Any faults which occurred in the insulation ought to be able to be detected when the current is flowing; this can be done by means of an electrometer. If the potential were reduced when a high resistance was connected to the pole of the dynamo, it would indicate the existence of a fault. A rough plate electrometer was all that was necessary for the purpose.

Mr. VARLEY explained that owing to the loss inside the tube filament, the result with such a filament could not be so good as with a number of fine filaments of the same bulk, unless, indeed, the tube were very thin, which was not the case in the Bernstein lamp.

Mr. MORTIMER EVANS considered that 200 candles per square inch from a filament was the highest power at which a lamp ought to be burnt. A great advantage existed in a thick filament, as a small flaw did not represent so great a percentage reduction in the diameter at that point as in the case of a small filament. The strain on a filament was somewhat similar to that in the case of railway metals, which might be knocked about to almost any extent, so long as the energy of the blows did not exceed a certain limit. It was, in his opinion, actually an advantage to have a mount at each end of the lamp, as in the case of the Bernstein invention.

Mr. SWINBURNE agreed with Mr. Bernstein to a certain extent. If a high volt lamp were run with a low volt lamp to the breaking point, the high volt lamp would go first. Draper's experiments proved that the light emitted from an incandescent surface was quite independent of the nature of the substance from which the light was emitted, so long as the temperature was the same. The blue glow referred to was not, he thought, due to occluded gases. An invisible discharge took place, he believed, in the lamps, no matter how good the vacuum. The roughness or smoothness of the surface of the filaments ought to make no difference in the light emitted. One advantage in a low-tension system was that meters could be used with great ease. The regulation of current in the case of arc lamps was an easy matter. As regards the Thomson-Houston regulator, it was necessary, in order to make it effectual, that the dynamo should have few sections.

Mr. J. MACKENZIE pointed out that if a fault occurred in the case of the series system, it would be impossible to say where the accident happened; moreover, the strain on the machine caused by an accident would be very severe. A series system combined with accumulators would be a most efficient arrangement.

Mr. SAYERS said that the insulation of the underground wires was *the* important point in the series system; but experiment would get over the difficulties which might be encountered. A loop test is easily made in a series system. The Brush current regulator he found to answer very well. An advantage in the series system is that the speed of the engine can be decreased in proportion to the number of lamps cut out.

Mr. BERNSTEIN, in replying, said that the existence of an electric shadow in the lamps proved that the disintegration of the filaments was an electric and not a thermal force. He agreed with Dr. Fleming that the quality of the carbon was an important point. Mr. Mordey's statement that lamps do not work so well in series as in parallel was not correct if the carbons were of proper quality. He did not consider that Draper's experiments prove the point at issue. He had tried the experiment of impregnating the carbon filament with magnesia, but did not obtain any improved effect. He agreed with Mr. Evans that the surface should be polished in order to get the best effect. The question of accumulators, he would point out, had nothing to do with the subject of his paper. As to Mr. Crompton's statement that no constant current machines had yet been made, he had been assured by Mr. Willans that there was no difficulty in this. He would draw attention to the point that, inasmuch as in the series system wires of large diameter for the house leads and lamp leads were necessary, there was smaller probability of an accident from a broken wire than in the parallel system. As regards the Electric Lighting Act, he thought the data there included could only have been obtained from laboratory and not practical experience. It was impossible to say what potential was actually dangerous; he had seen a man knocked down by 50 volts only. In America no accident had ever happened from the use of high tension currents.

The meeting then adjourned.

REPLY OF THE PRESIDENT TO THE DISCUSSION ON HIS INAUGURAL ADDRESS ON SELF-INDUCTION.

Lord Rayleigh, while fully recognising the importance of the subject of my researches, seems not to have seized all the details of the method which I have employed, or the meaning of some of the terms which I have used. Prof. Forbes has already replied to that portion of his remarks; but in his communication dated February 24th, Lord Rayleigh assumes that "the disturbance depends upon the rapidity of vibration, so that, in the case of ordinary mixed sounds, silence can be attained only approximately." Prof. Silvanus Thompson has also asked me if the results depend on the rapidity of the contacts. In reply, I must state that in point of fact the rapidity of the contacts have no influence on the result, providing they are not more rapid than the rise and fall of the extra currents.

Let us suppose that, instead of rapid contacts, we make and break the contact once only per minute, then, on making or breaking the contact, we shall hear a single blow or tap on the telephone; and if the communications of the bridge and telephone are arranged for the *stable* period, this sound will not be heard when the resistance of the bridge is perfectly adjusted. Suppose that we now change the communications so as to observe the *variable* period, still making and breaking contact but once per minute, we shall then find (if there is self-induction taking place in the wire under observation) that we have no longer silence at the previous adjustment of the bridge; if this disturbance is due only to the extra currents, we can reduce it to zero by throwing in from the sonometer an opposite momentary secondary current of *equal* value; but if the disturbance is due only to the resistance being changed, then we shall have to move the slide on the bridge until we have again perfect silence. In many cases we have to deal only with the extra currents, in others there is a far greater change in the resistance of the wire than in the force of the extra currents. Both can be adjusted separately or alone, but no change of the resistance slide will compensate for the induced currents, nor will any change of the sonometer affect in the slightest degree the required adjustment of the resistance slide; it is the first portion of the current that we are measuring by means of the telephone, or its action at the moment of making or breaking contact.

The object of my researches was to observe what takes place at the first instant of contact. To this the telephone responds with admirable precision, whereas, as I have already said, a galvanometer would be useless for such delicate experiments as I have made, where it is necessary that the self-induction of a few inches of straight wire may be readily perceived and accurately measured. The rate of speed of contacts, therefore, can be increased up to the point where the duration of the contacts is at least as long as the duration of the extra currents. In short wires the duration in time of the extra currents is exceedingly small, and much less than any duration of contact that I have used; a large electro-magnet would require a lengthened contact and a different method. The only advantage, therefore, of short contacts is the constant repetition of sounds or beats, enabling us the more readily and rapidly to find the required balance.

All of the important points mentioned in my paper have been verified by independent methods, and they have also been repeated with slow and rapid contacts, as well as with widely different external resistance in the battery circuit; but I wish to show that the induction bridge gives perfectly reliable results, and that its readings can never be changed or misunderstood.

I have chosen a fine German silver wire for the resistance bridge, because German silver has (even in the form of large wires) an extremely low inductive capacity; and this, when the wire is fine, is again reduced to a mere fraction as compared with what it would be in wires of 1 millimetre diameter of different metals. To test the instrument, place a piece of similar sized German silver wire in the arm, A B, we do not then find any trace of self-induction, as all the four arms of the bridge are equal; we may vary its resistance by shortening the length of the wire, but the bridge can only then be adjusted to zero by moving the resistance slide. Under these conditions there is no difference perceived between the stable and the variable period, as the changes produced are equal on all sides. Let us now replace this German silver wire between A and B by a copper wire of the same resistance, we then find that the stable period gives exactly the same zero as previously, but that a disturbance takes place in the *variable* period, and that this cannot be adjusted by the *resistance* slide, but that it is completely reduced to zero by the opposed induction current of the sonometer. Again, if we heat this same wire its resistance is changed, and can only be compensated by moving the resistance slide; if we make this wire into a loop or a parallel return, there is no change in the resistance, but the *self-induction is reduced* at once, as shown by the sonometer; winding this wire in a coil increases the induction, and, within certain limits, we may perceive no change in its resistance, whilst its *self-induction has increased* several hundred per cent. Now, suppose we increase the resistance by heating and the induction by coiling the wire, we have then two distinct effects of known values, and the measurements given by the resistance slide and by the sonometer are precisely those which would have been given by either when measuring them separately; and this again proves that where we have a case of change of resistance it can only be met by adjusting the resistance slide, and where we are measuring the electromotive force of the extra currents they can only be compensated for by the use of the sonometer.

The cause of the extra or momentary increased resistance of a wire during the variable period can be explained. The current, on entering the wire, produces an extra current of an opposite name, and that this really opposes the passage of the current is proved by the upsetting of the previously balanced bridge; there is, in fact, in this moment less resistance on the opposite side, and the balance can only be restored by the resistance slide.

There are, however, cases where this effect is entirely reversed, in which there is less resistance in the variable than in the stable period; this occurs when we are testing extremely fine wires with powerful currents, for the steady current heats the wire, thus introducing an extra resistance, which does not take place to the same degree with short contacts as in the variable period; but, as I have already said, care must of course be taken to avoid all such sources of error; and if we understand the subject, and know exactly where to look for errors, there should be no difficulty in constructing a bridge perfectly free from experimental error.

The instrument and method which I have employed have a great advantage over any previously used, as from the exquisite sensibility of the former we are enabled, not only to verify all the results obtained by previous observers from their experiments on coils, but to do that which no other instrument or method has previously enabled us to accomplish, viz., to observe the self-induction of straight wires and the laws of its reactions (as in the contiguous portion of the same current in straight wires and sheets) entirely separate and distinct from the mutual reactions of one part of a coil upon another. These I have shown to be quite different, as an iron coil has less self-induction than a copper one, whilst in straight wires the reverse is the case. We must not neglect this all-important point, for in no way do my researches contradict well-known results, they simply go further, and show the physical reasons for certain phenomena; and where theory has failed to predict, or previous experiments to show, this has been due simply to the fact that no instrument existed sensitive enough to record or measure the effects which take place in the self-induction of a comparatively short wire free from external reaction.

Self-induction in coils has been a subject which I had of necessity to study in relation to my printing telegraph instrument. The movement of my armature being extremely rapid, produced extra currents of sufficient force to trouble other instruments on the same line. I finally vanquished this difficulty in 1860 by an arrangement whereby the armature, in rising, instantly short-circuits its own electro-magnet, and by mechanical means (peculiar to the instrument) is entirely separated from the line, placing the line at the same time direct to earth or battery, but leaving the electro-magnet open, so that the return of the armature produces no extra currents that can affect the magnet or line. This has answered perfectly, and has been in use on all of my instruments since 1860 up to the present day. I have also used, since 1861, divided coils, whereby the current is passed through both coils in parallel, and not in series; this I use on lines less than 500 miles, not simply because of the diminished resistance, but because I found from experiments much less disturbing influence from the extra currents. I have, however, lately, by the aid of the induction bridge, been not only enabled to measure this difference, but to trace it to its true cause, and the following table gives a representative result obtained from numerous coils of different sizes and resistances, and with or without iron cores:—

Coils formed of 3 mètres Silk-covered Copper Wire, 1 mm. in diameter, each coil being 3 centimètres diameter.	Comparative Force of the Extra-Currents.
One coil alone	100
Two similar coils in series	174
Two similar coils in parallel, but separated 5 cm. from each other	55
Same two coils in parallel, but superposed ...	81
One single coil of thicker wire of exactly the same form, length, and resistance as the two coils in parallel	75

The table shows an increase of force when two coils are in series, but not quite double, as a portion is reduced by the increased or added resistance. This is a well-known effect; but an interesting result is shown where the two coils are parallel and separated, giving then 32 per cent. less induction than the same coils superposed, and also 26 per cent. less than that of a single coil of precisely the same resistance. We can easily explain this, and trace the effect to the reactions of contiguous coils on each other.

I have shown a remarkable difference in the inductive capacity of different metals when formed into wires of the same diameter; and as the order follows that of their respective specific resistances, it became an interesting study to know what would be the result if all the wires were of the same length and resistance. It is necessary to employ the same length, as the induction increases with the length: consequently a copper wire, compared with a brass wire of equal resistance, and therefore of greater length, would show a great difference in their inductive capacities. There are, however, several methods, free from experimental errors, which I have employed in this investigation.

If we take wires of different non-magnetic metals of the same length and diameter, and reduce them to the same resistance by an added resistance comparatively free from induction, such as carbon, I find that there is apparently no difference whatever in the inductive capacity of the different metals, all (yet tried) giving by this method very nearly the same result; but in this case we have added an external resistance, and thus prevented any difference of action due to the different density of the current in metals of high and low resistance.

If, instead of an added external resistance, we take wires of the same length and resistance, but of different diameters, we then find a marked difference in their inductive capacities; for instance, a pure copper wire, compared with a brass wire of double the diameter, shows a marked higher force in the copper wire. We might naturally believe that the brass wire, from its larger diameter, would give higher results than the smaller copper wire; but if we have thoroughly seized the importance of the phenomenon which I have demonstrated of the reaction of con-

tiguous portions of the current on each other, we can easily prove that the larger the diameter of the wire the less will be its proportionate reactions, so that, whilst the resistance decreases directly as the increase in section, the reactions of the currents upon each other become *less* as the diameter increases, the resistance diminishing as a straight line, whilst the induction would follow a curve similar to that shown in the diagram.

The following table shows the electromotive force of the extra currents on wires and strips 1 metre in length, a chemically pure copper wire of 1 mm. diameter being taken as the standard of 100, to which all the rest were compared:—

Wires of the same diameter, but of different resistance—1 metre in length.		*Wires* of the same resistance, but of different diameters—1 metre in length.	
Soft Swedish iron ...	500	Soft Swedish iron ...	400
Copper	100	Copper	100
Brass	65	Brass	88
Lead	50	Lead	81

Strips of the same width and thickness, but of different resistance—1 metre in length.		*Strips* of the same resistance and thickness, but of different widths—1 metre in length.	
12 mm. wide, $\frac{1}{10}$ mm. thick.		$\frac{1}{10}$ mm. thick.	
Copper	60	12 mm. wide	Copper 60
Brass	48	42 „ „	Brass 45
Iron	45	72 „ „	Iron 39
Lead	35	96 „ „	Lead 29.

In the above table, wires of the same diameter follow in the order of their resistance, iron alone being the exception; the same order is preserved in wires of the same resistance but of different diameters. In the latter case there is a nearer approach to equality, but they still show a difference of from 12 to 19 per cent., and whilst the non-magnetic metals have increased their inductive capacity with increased diameter, iron has fallen 20 per cent.; consequently, wires of different metals of the same resistance have not the same inductive capacity, owing, I believe, to the action of contiguous portions of the current, as I have already shown.

(To be continued.)

NEW PATENTS—1886.

4579. "Apparatus for converting ordinary trembling electric bells into continuous ringing electric bells at will and also for other purposes." H. J. ECK, C. B. CALLOW, H. WRIGHT. Dated April 1.

4880. "Apparatus to employ electricity for curative and remedial purposes." R. DURLING. Dated April 7.

4884. "Dynamo-electric machines." J. PLATT, J. HOPKINSON, E. HOPKINSON. Dated April 7.

4899. "Acoustic telephone ('Beehive')." S. VYLE. Dated April 8.

4915. "Self-acting electric burglar alarms." J. MAY, G. J. HUTTON. Dated April 8.

4937. "Conversion of heat energy into electrical energy and apparatus therefor." W. R. LAKE. (Communicated by W. E. Case.) Dated April 8. (*Complete.*)

4939. "Lightning arresters." G. A. MASON. Dated April 8.

4946. "Telephonic and telegraphic call apparatus. C. L. BAKER. Dated April 9.

4988. "Electric apparatus." A. WRIGHT. Dated April 10.

5025. "Controlling speed of engines or motors by electricity." J. RICHARDSON, R. H. C. NEVILE. Dated April 10.

5063. "Telegraphing apparatus used in connection with steam engines." W. CHADBURN. Dated April 12.

5078. "Electric lighting apparatus for use in wheeled vehicles." R. WEBER. Dated April 12.

5089. "Electric arc lamps." F. FESQUET, S. J. COMTE OSTROROG. Dated April 12.

5090. "Measuring the consumption of electricity." H. SERRIN, F. FESQUET. Dated April 12.

5091. "Electrical governors for preventing the racing of marine engines." A. M. CLARK. (Communicated by E. A. Wahlström.) Dated April 12.

5092. "Thermo-electric generators." A. RUST. Dated April 12.

5093. "Telegraph transmitters." G. W. BALDRIDGE. Dated April 12. (*Complete.*)

5116. "Electrical toy." R. DIPPLE. Dated April 13.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

2985. "Improvements in electric arc regulators." J. G. STATTER. Dated March 6. 8d. The inventor actuates the improved mechanism by means of a solenoid or by an electro-magnet, either series shunt or compound wound. The power of the solenoid or electro-magnet, as the case may be, is appplied to a link or to two or more links braced together. This arrangement works about a fixed spindle, and bears upon and controls the position of a saddle working in guides, or a guide such as a tube. Brakes (their number being the same as that of the brake wheels) work in bearings attached to the saddle; spindles for the brake wheels are also attached to the saddle and to each break wheel a pinion is rigidly attached. This pinion gears with a rack rod. Each link of the frame has a projection at right angles, or nearly at right angles, to its length forming a bell crank about its bearing and a stud or pin is put into this projection. To this stud or pin the flexible attachment to the brake is fixed, and as the saddle is lifted up by the thrust of the frame upon it the bell crank pulls the brake upon the wheel by means of its pin and flexible attachment. As the link descends the crank moves round, slackens this attachment and raises the brake, allowing the wheel to revolve and the rack rod to descend.

2188. "Improvements in magneto call bell apparatus." H. T. O. FRASER. Dated February 17. 8d. The chief feature of the apparatus is the substitution of a cord chain or other equivalent, in conjunction with a clock spring, India rubber, or any other suitable spring, or elastic substance, for rotating the armature of the generator, in place of the geared or friction wheels or other similar appliances hitherto employed.

2490. "Improvements in apparatus for use in distributing currents of electricity." R. E. B. CROMPTON. Dated February 24. 8d. Relates to such parts of apparatus used in controlling the supply of currents of electricity as are usually called collecting and dividing switch boards or commutator boards, and consists more particularly in the arrangement and construction of these boards in such manner that all the commutations and connections can be made by comparatively nonsparking and easily renewable switches in place of the plugs or connections of like nature which have hitherto been necessarily used in all the more complicated forms of commutator boards.

2765. "Improvements in and relating to electrical accumulators or secondary batteries." W. R. LAKE. (Communicated from abroad by A. Marchenay, of Paris.) Dated March 2. 6d. Relates to electrical accumulators or secondary batteries in which plates of crystallised chloride of lead are employed, and to the preparation of the said plates.

2970. "Improved insulated electric conductor for underground and other purposes." E. W. LANCASTER. Dated March 6. 8d. The inventor takes a suitable length of wire or rod of copper or other metal of good conductibility and inserts it either bare or covered with a coating of shellac, paraffin, gutta percha, India rubber, or any other good non-conducting material into a length of dried wood or prepared fibre provided with a groove or slot cut to a suitable size throughout its entire length to receive it. The groove or slot is then filled in flush or covered with a slip of wood which is fixed or glued making the section of the whole length square, angular, or any other shape. The whole is then well dried and soaked in an insulating solution prepared for rendering it perfectly free from dampness or moisture, and so that no such dampness or moisture can penetrate it afterwards. The whole being again dried and tested, is then inserted into a prepared well-dried pipe or tube usually of cast or wrought iron either plain or coated with paint or enamel inside the wood being of square or angular section touches the pipe or tube at the apex of the angles only, and this only at different intervals along the whole length, thus minimising the chance of contracting the copper core with the outer piping. This then leaves segments of unoccupied space throughout the entire length of the pipes or tubes. These are filled under pressure with an insulating and dampproof preparation forcing out all air or moisture that might be in the pipes or tubes providing against any such entering afterwards, or a vacuum may be formed only. The invention also consists of methods of jointing the lengths.

3379. "Improvements in distributing electricity, and apparatus therefor." W. P. THOMPSON. (Communicated from abroad by C. Zipernowski and M. Déri, both of Budapest.) Dated March 16. 1s. 1d. Induction bobbins are grouped in secondary distributing stations, and the primary bobbins of such a station of second order are intercalated either successively in series or parallelly. In the first case the secondary or induced bobbins of all the stations must form only one local circuit, the induced bobbins may be grouped in quantity or in series. In the other case, when the primary bobbins are arranged parallel, each induced bobbin may form a special secondary circuit, or, as in the first case, all the induced bobbins of such a station may be united to one common local circuit. The places of consumption are intercalated in the local current, in all cases, in a parallel manner. The main rule is, that the several groups of induction bobbins or the different stations of second order form, in reference to the main distributing line of the primary current, always only branch circuits. A distributing net consisting of an optional number of parallelly arranged branch stations, and of an optional number of local cir-

cuits separated from one another is thus obtained. The stations of second order are made independent from one another by maintaining invariable the tension of the primary current, where it enters into the secondary stations. To obtain an automatic regulation of alternating currents in a satisfactory manner, that is to say, to receive an invariable tension of the current in certain points of the net, even if the effect of the generator and the resistances in the circuit are variable, the following new and simple means are applied. The main current to be regulated is made circulating through the bobbins of a so-called alternating current secondary generator or inductor, before it reaches the working place. The second bobbin is wound parallel to the first round, and a common iron core is intercalated in the exciting circuit. The alternating current indirectly produced by the second spire, that is to say, secondarily induced by the main current is turned into the same direction by a commutator adapted to the shaft of the machine. If the secondary spire is intercalated in the exciting circuit in such a way that the current induced therein is added to the exciting current, the magnetising will change in the same sense as the intensity of the main current. The magnetising will change in the contrary sense, when the secondarily induced current is circulating opposite to the exciting current. The first arrangement serves for regulating the tension of the current, the second arrangement for regulating the intensity thereof.

3599. "Improvements in electro-motors or dynamo-electric machines." A. Reckenzaun. Dated March 20. 8d. Has mainly for its object the production of a novel type and improved construction of field magnets, which are laminated or built up of thin bars or plates, thus ensuring the advantages of rigidity, simplicity and efficiency, combined with small weight of material.

3625. "Improvements in supports for the shades and bulbs of incandescent electric lamps." A. Swan. Dated March 20. 8d. The inventor makes the shade support in two parts, consisting of an outer and an inner tube, the outer tube having a splayed out or conical part, and the inner tube being provided with corresponding arms between which splayed out or conical part and arms the shade is held.

3764. "Improvements in electric fuses." J. Nacnab and D. Hickie. Dated March 24. 11d. Relates to improvements on the present methods of constructing low and high tension electric fuses for the purpose of insuring greater reliability of action and more efficiency in manufacture, also for securing more freedom from damage and better contact between the poles of the same than has hitherto been obtained, besides neutralising any chemical action or decomposition that might take place between the gun-cotton or priming composition employed, and the substances of which the plug or wire holder case is composed.

3765. "Improvements in the manufacture of filaments or carbons for incandescent electric lamps." G. Davidson, R. C. Jackson and J. B. Duncan. Dated March 24. 8d. The material which is to be carbonised to form the filaments is cut into uniform strips by causing it to revolve against a cutting instrument or by causing cutting instruments to rotate against it.

3845. "Improvements in thermo-electric generators and in insulating materials." H. Woodward. Dated March 25. 8d. The improvements have reference, 1st, to the construction and insulation of the chamber or casing of the generator which surmounts the furnace or source of heat; 2nd, to a special form or construction of the elements; 3rd, to the manufacture of a novel material or composition for insulating the elements one from the other, but which material or composition is equally applicable to insulation in other electrical apparatus; and, 4th, to a mode or method of connecting the entire series of elements, or any portion thereof, when built up, with the terminal posts.

3854. "Improvements in electric governors." W. Hartnell. Dated March 25. 11d. The current is made to control the position of an instrument, and this instrument, when it has been correctly placed, is afterwards, by the power of the engine, motor or current itself, applied to move the throttle valve or other mechanical part of the engine or motor, or it may be of the dynamo relay resistance or the like which has to be moved to regulate the current.

3857. "Improvements in electrical switches." S. Z. de Ferranti. Dated March 25. 8d. According to this invention, the inventor makes electrical switches in such a manner that by the first movement of their knob or handle (which has to be turned or moved to make or break a circuit), energy is caused to be stored up in a spring or springs without affecting the contacts until the springs have been brought into such a state of tension or compression that they overpower the resistance which retained them, and that they then fly, or cause other parts to fly, quickly into position to make or to break a circuit as the case may be.

4137. "Improvements in methods for transforming, distributing, controlling, and utilising electric and magnetic force, and in apparatus or means employed therefor or in combination therewith." J. S. Williams. Dated April 1. 6d. Has for its object the dealing with the development, conduction, control, and use of magnetism in a manner analagous to that which is employed in dealing with electricity—or other forces. The inventor constructs electro-magnets or electro-magnetic systems so that their cores, or both cores and conducting or energising elements may at will be coupled (as galvanic batteries or dynamic or other generators are at present, or as other electric appliances, for instance, lamps, &c., are, viz.), in series, compound series of multiple series, or parallel circuit.

CORRESPONDENCE.

Proofs that Electricity is an Element.

Referring to my letter published in your number of the 9th inst., I have some further facts on this subject, which call for attention.

MM. Cailletet and Bouty described before the Paris Academy of Sciences, "numerous experiments made with mercury, silver, tin, aluminium, magnesium, copper, iron, and platina, proving that the electrical resistance of these metals decreases regularly when the temperature is lowered from 0° to — 123° C., and that the coefficient of variation is apparently much the same for all. They further stated that "it seems probable that the resistance would become extremely slight at temperatures lower than 200°, but they had not carried their experiments so far." The action of the freezing mixture of — 123° C. on a copper wire would be two-fold :—*first*, the normal amount of latent heat within the wire would be greatly reduced; *second*, the molecules of the copper would be drawn closer together. Notwithstanding that the molecules of the copper would be drawn closer together, and thereby leave less space between or around them for the passage of electricity, yet the resistance to the passage of the electricity through the wire was diminished by the removal of part of the latent heat which was within the copper. This proves that heat is in some way the obstructing element which prevents the free passage of electricity through metals.

There is another important phenomenon bearing on this subject. In the *Scientific American* of the 27th ult., there is a letter to the Editor, from a Mr. Chas. L. Chapin, giving an account of certain engineering operations he was shown in Bermondsey, when he was in this country, in January, 1874. All persons acquainted with engineering know how much time and labour are required in the operation of fixing, on the face plate of a large turning lathe, the pieces of metal which are either to be turned or bored. A Mr. Werdermann formed the idea, and patented the plan of fixing these pieces of metal by means of powerful electro-magnets. These large magnets were arranged on the face plate of the turning lathe, so that when a piece of metal to be turned or bored was placed in its proper position on the face plate, the electricity was then switched on to the electro-magnets, and they advanced and held the piece of metal firmly without any other fastenings, thereby saving much time and labour. Owing to this invention a discovery was made of a phenomenon which Mr. Chapin says has remained unexplained until now, and he has given the information to the Editor of the *Scientific American* in hopes that an explanation will be found. Every scientist knows that Count Rumford's attention was first directed to the study of heat by the very great amount of it which is produced at the boring of a hole through a mass of metal. In the engineering shop in Bermondsey, Mr. Chapin saw masses of iron bored and turned, during which processes neither the bored and turned iron, nor the chips from them, showed any signs of heat, and the tools used in doing the work of turning and boring were so cool that they did not require to have a stream of water kept running on them, as is commonly necessary when this work is done by the common kind of turning lathes. At the end of Mr. Chapin's letter, he writes "Mr. Werdermann's solution of the matter was simply—it was supposed that the heat of the cutting tools was absorbed by the magnetised condition of the iron which formed the keeper of the heads of the magnets." Mr. Chapin adds in his letter, "Was this the true solution?" I reply, it is so far true, but it does not explain why these iron electro-magnets should absorb an amount of heat which cannot be absorbed by much larger masses of unelectrified iron. The reason why that large amount of heat disappeared was on account of the attraction which electricity has for heat. The currents of electricity passing through the wires of the electro-

magnets absorbed all the free heat which came within their reach from the metal, when the boring and turning was taking place, and kept the tools cool in consequence.

This discovery of the late Mr. Werdermann places beyond all doubt the fact of the great attraction which electricity has for heat.

Whether electricity and heat be or be not each of them a kind of imponderable matter it is manifest, from the facts narrated in this and my previous letter, that electricity and heat are each distinct and separate elements which cannot be transformed into one another as has been previously supposed to be the case in accordance with the theory of energy as at present promulgated.

James Johnstone.

8, Merchiston Park, Edinburgh,
April 12th, 1886.

P.S.—In the last paragraph of my previous letter there is the question, "What induced the latent electricity to leave the oxygen?" The last word should have been *ozone*, not oxygen.

J. J.

The "Valve" Telephone.

With reference to his letter in your issue for March 12th, perhaps Mr. Sydney F. Walker will be good enough to say wherein lay the difference between the good Valve transmitter which he describes, and the other which was put up by the inspector, and which never spoke properly. Was the latter of the same construction as the former, only with a metallic instead of a carbon ball, or were the two different in form? I ask this question, as, from curiosity, I am anxious to ascertain whether the "New" company are in any way making use of silicium or other bronzes instead of carbon. They have given out that they prefer the former, but seem universally to use the latter. Again, Mr. Walker mentions the fact that in the trial he refers to the whole of the battery was in the main line, which occasioned the continuous ringing of the intermediate bell when the extreme stations were talking. By this are we to understand that receivers, transmitters, and batteries were arranged in simple circuit in series in the way the London and Globe Company used to work their Hunnings's transmitters and "Mechanic" receivers, or were the "plug" arrangement of Prof. Thompson and an induction coil in use?

An answer to the above from Mr. Walker, or from Mr. A. W. Hine, who seems to have had similar experiences, will doubtless interest others besides

"Telephonist."

Professor Hughes on Self-Induction.

On January the 28th, of this year, Professor D. E. Hughes, as the newly-elected president of the Society of Telegraph Engineers and Electricians, read, as his inaugural address, a paper entitled, "The self-induction of an electric current in relation to the nature and form of its conductor."

I regret that I was unable to be present at the reading of the paper, or on any of the evenings that were devoted to the discussion of the same, but, if I understand Professor Hughes's meaning, the object of his paper is to prove that conductors of different metals and of different forms vary in their resistance in accordance with the nature of the electrical conditions under which they are placed. For instance, the resistance of a conductor would be different for a permanent current to what it would be for intermittent currents, the amount of the difference depending on the form of the conductor, *i.e.*, whether solid wire, strand, or ribbon, or a combination of two or more such conductors.

The apparatus for his experiments consisted of a specially constructed induction bridge, in which the galvanometer was replaced by a telephone, and it was found to be impossible, however accurately the wires were balanced for a constant current, to silence the telephone when intermittent currents were passing in the battery circuit. If the galvanometer be used, a perfect balance is obtained both with constant and intermittent currents. In Professor Hughes's arrangement the sound of the telephone can only be reduced to a minimum; consequently, to produce silence he sends through the circuit counter currents produced by electro-dynamic induction, and then again alters the length of the wire in circuit until no sound is heard in the telephone, and the true resistance of the wire is supposed to be thus ascertained. The counter currents are set up by two bobbins of wire, a primary and a secondary one, the primary being in the battery circuit and the secondary in the telephone circuit, so that, by altering the relative positions of the two bobbins, variations in the currents of the telephone circuit can be produced.

Now, some very remarkable results appear to have been obtained with this novel combination of an ordinary Wheatstone bridge and the professor's "induction balance," and, from these results, Professor Hughes lays down the following startling propositions for the guidance of the practical telegraph engineer and electrician:—

"A solid rod of iron is the worst possible form for a lightning conductor."

"The conductor, if of copper, should be of ribbon form, or, if of iron, of numerous stranded wires, or a wide ribbon of similar conductivity to that of the copper."

"That there is a remarkable difference in the resistance of a wire during the 'stable' and the 'variable' period," or, in other words, with the results obtained with a constant current or intermittent currents.

"An iron wire has, with rapid currents, *more than three times* the resistance during its actual work than that supposed to be its true resistance."

"The more rapid the contacts of a telegraphic instrument the greater will be the difference between copper and iron."

"A solid iron wire is unsuitable for telegraph instruments requiring extremely rapid currents."

"Copper would reign supreme if it were not for the fact that stranded iron wires have greater rapidity of action than copper."

Now these propositions, which I have quoted, are so opposed to all my experience that I at once put them to a simple, but, I think, efficient practical test. A circuit was made up of an astatic mirror reflecting galvanometer, a battery of one Grove cell, a rapid interrupter, and a strand copper conductor of about 250 yards in length insulated by suspension in the atmosphere. The interrupter was so constructed that from one hundred to two thousand interruptions of the current could be made per minute.

The internal resistance of the battery was ·2 of an ohm, and the resistance of the galvanometer ·1, whilst the resistance of the conductor was 1·07 ohms, so that the total resistance of the circuit was 1·37 ohms. Under these conditions the deflection of the galvanometer was obtained both with a constant current and with rapidly intermittent currents. The wire under test was then removed, and conductors of different metals and forms substituted for it, each conductor having identically the same resistance as measured by a Wheatstone bridge, and it was found that whatever the nature and form of the conductor, the deflection obtained on the galvanometer was the same, showing that the resistance of a conductor of constant section and material is strictly proportional to the length and inversely proportional to the area of its cross section, or, in other words, inversely proportional to the weight per unit length, and that, whether it is carrying a constant current or intermittent currents. It therefore follows that, having ascertained by well-known laws the resistance necessary to carry a desired current, it matters not, electrically, of what metal or form the conductor is made. Of course, I am referring to aerial wires for telegraphic purposes or for lightning conductors. For the conductors of submarine telegraph

cables of course these remarks would not apply, but that has nothing to do with the present case. Having satisfied myself in the matter, I took no further notice of it, thinking that the erroneous impressions Professor Hughes had conceived were of such a nature that he would soon discover his mistake and immediately take means to rectify the same. But, now that I find the subject is likely to be re-discussed, I think it well to publish the results of my experiments, which prove, to my mind, that Professor Hughes has been misled in endeavouring to obtain reliable results by a combination of electro-dynamic, electro-dynamic-inductive, and electro-magnetic-inductive currents, without a due regard to the laws which govern the same.

Willoughby Smith.

April 12th, 1886.

[We have commented upon this letter in "Notes."—EDS. ELEC. REV.]

I observe in your last issue that Profs. Ayrton and Perry publish some remarks made by Prof. Ayrton during the discussion on Prof. Hughes's inaugural address, giving a very simple and ingenious proof of the fact that if by reason of self-induction or otherwise the current density is not uniform throughout the cross section of the conductor, the power consumed in producing heat is always greater for the same total current, and that, therefore, the resistance encountered by this current is greater than with a uniform current density.

This is, in fact, quite self-evident, if we consider the conductor as formed of several parallel conductors together equivalent to it, and that in some of these opposing E.M.Fs. prevent the passage of the proper share of current.

I see, however, that Prof. Ayrton mentions an experiment made by me in connection with this subject, and as he has not quite exactly detailed the experiment as actually performed, it may perhaps be desirable to do so.

At the time this experiment was performed, now some years ago, I was engaged in attempting to measure the efficiency (or possibly you would call it *strain*) of the lampe soleil, and also of the Gramme alternating dynamo separately.

In order to check the Siemens dynamometer I constructed the following very simple instrument :—I laid out along a board a flat band of German silver, of ample sectional area to take the largest current I proposed to measure without appreciable heating.

I also took a small brass tube, with a magnifying lens fixed at one end, and a $\frac{1}{4}$-inch length of ·0014-inch iridio-platinum wire fixed between two poles of stout copper wire near the other end, which was closed. The eye piece was enlarged so as to fit closely round the eye, and thus all light was excluded from the tube when applied to the eye.

This arrangement I call my "Veracity Detector."

One lead from this was attached to one end of the German silver band and the other was slid along it, starting from this end until the radiation from the iridio-platinum wire was just visible as a sort of dusky red.

This was first done with continuous currents, measured both by the electro-dynamometer and by other methods, and a scale of currents marked along the German silver band, which were of course inversely as the distances from the end approximately and afterwards with alternating currents. I cannot at the moment lay my hand on the records of these experiments, but remember perfectly that the readings on the electro-dynamometer were low for the alternating currents in every case. I am not quite so certain how the difference was affected by an alteration in speed of alternation, but have got all the apparatus and intend when opportunity serves to investigate the question more completely.

The "Veracity Detector" is so named because one can often "catch out" a youthful and enthusiastic experimentalist straining his eye to catch the first faint dawn of dusky red by slightly lifting the slider from the conductor occasionally when just about the critical point.

This application will be found useful by professors, and is not patented.

P. Cardew.

Chatham, *April 12th*, 1886.

[We should not speak of the *strain* of a sun lamp.—EDS. ELEC. REV.]

Dynamo Testing.

I hasten to thank Dr. E. Hopkinson for his courteous reply to my letter of the 23rd ult., and to assure him that he has correctly apprehended my difficulty. In the present state of our knowledge regarding the action of dynamos and motors there are, however, grave objections to his method of surmounting it, and I therefore venture to again trouble you on the subject, as the method used may perhaps be largely adopted, and more especially as the point raised has a direct bearing on the question, which has been much discussed lately, of the relative efficiences of the same machine worked as a generator and as a motor.

The full problem may be briefly stated as follows :—

Let e and e^1 = the commercial efficiencies of the generator and motor respectively ;
„ V and V^1 = the measured potential differences at terminals of generator and motor ;
„ i = the current flowing in the external circuit ;
„ i_m = the current flowing in the motor field-magnets ;
„ r_m = the resistance of the motor field-magnets ;
„ w = the power supplied by the belt ;
„ W = „ „ „ „ motor to generator ;

Then
$$e = \frac{V\,(i + i_m)}{W + w} = \frac{A}{W + w}$$
$$e^1 = \frac{W}{V^1\,i + i^2_m\,r_m} = \frac{W}{B}$$

where A and B can be calculated from the electrical measurements.

Whence
$$e = \frac{A}{B\,e^1 + w}$$

or
$$B\,e^1\,e + w\,e = A \qquad (1)$$

a *single* equation only to determine the *two* unknown quantities e and e^1.

To surmount the difficulty here indicated, Dr. Hopkinson assumes that the integral loss of converting mechanical into electrical energy, and *vice versâ*, is the same in both armatures. The equation might also be solved by assuming $e=e^1$, which, in the present case, is nearly the same thing. But both these methods beg the whole question referred to above, and the first leads, in some of the published figures, to the curious result that the efficiency of the motor is higher than that of the generator. Also, it is not quite correct to say that the only effect of dividing the loss in any other proportion would be to increase the efficiency of one machine, and diminish that of the other by the *same* percentage. Taking the example selected by Dr. Hopkinson, the constants in equation (1) are A=40013 B=38896, w=6604. If, now, we assume e=95 per cent. (an *increase* of 1·77 per cent.), we find e^1=91·3 per cent. (a *decrease* of 2·07 per cent.), and the efficiency of transmission is slightly diminished. The difference in *this* example is not great, but, as Dr. Hopkinson has himself remarked, where the total loss is so small a slight difference becomes not altogether unimportant. Also, it is easy to see that wherever the efficiencies do not range so high the results, worked out on Dr. Hopkinson's assumption, may be rather wide of the mark, and it is on this account that I have ventured to trouble you again. As the assumption last made (e=95 per cent.) is very nearly the most favourable one possible for the generator, and, consequently, the least favourable for the motor, the figures given show

very nearly the limits of the relative efficiencies of the two as calculated from this particular test, assuming that the value of *w* is correct, about which there appears to be some slight doubt.

In conclusion, I wish to say that the above is not written in any captious spirit, nor with any wish to detract from the high efficiency which must be conceded to the motor in whatever light the figures are interpreted, an efficiency which is, I believe, by far the highest yet recorded. My only desire has been to point out an error which may possibly arise (and be a serious one) if the method be applied to less efficient machines, and more especially if the machines coupled together are dissimilar.

R. Mullineux Walmsley.

Finsbury Technical College,
April 13*th*, 1886.

Rapacity of Telephone Companies.

In your issue of April 9th, we noticed a paragraph headed "Mechanical Telephones," signed "Iron," by which it would appear that users of a mechanical telephone have been threatened with proceedings by an agent of one of the electrical telephone companies, unless "Iron" removes the mechanical telephone he is using.

We notice your editorial note at the bottom of the paragraph referred to, and we take this opportunity of stating that this is not the only instance in which electrical telephone companies or their licensees have endeavoured to frighten users of mechanical telephones. In the instance referred to, the United Telephone Company wrote a very strong letter to a certain bank using our instrument, threatening them that unless it were at once removed, they would institute proceedings against them, for an infringement of their (the United Telephone Company's) patent rights. On learning these facts, our solicitors were instructed to at once communicate with the United Telephone Company, which they did, and after a correspondence of some length the United Telephone Company withdrew all suggestion of infringement, and our customer is about having our instrument restored.

We think the above facts will show that the telephone companies, more especially those that are working under the United Telephone Companies' patents, are using their utmost endeavours either by fair or foul means to prevent the legitimate use of rival instruments, even as in the present instance obviously and admittedly no infringement of the patent held by them.

The Mechanical Telephone Company, Limited,
WM. J. BURNSIDE, *Managing Director.*

London, 13*th April*, 1886.

[It requires some degree of hardihood to hazard an opinion adverse to the success of the United Telephone Company in any legal action it may enter upon; but we scarcely think even Mr. Justice North would be able to discover the combination of diaphragm and Edisonian tension regulators in the mechanical telephone. A "North" diaphragm there undoubtedly is, but no Edisonian tension regulators which have yet been described in Court or elsewhere. We are not surprised, however, that the owners of the combined patents try to frighten any semblance of opposition out of the field when no other means of destroying it are available.—EDS. ELEC. REV.]

Primary Batteries.

I am endeavouring to elucidate the present condition of electric lighting by means of primary batteries. For this purpose I am collating information concerning them with a view to publishing the result in connection with a book I am engaged on.

At present the subject is clearly in the realms of the unknown, and I should be very glad if those of your readers who are able to furnish any reliable data would kindly communicate with me as under. The testimony of manufacturers as to the excellencies of their batteries is not solicited. I am already acquainted with the value of their superlative hyperboles.

The information I am anxious to obtain is:—

Have any primary batteries been successfully employed for two years? If so, where, and how many lamps?

The same questions as applied to one year's working, or even again for, say, eight months?

What is the largest number of lamps now worked from a primary battery, and for how long has it been in operation?

Again, can any places be named in England where primary batteries have been working over, say, eight 10 C.P. lamps successfully for six or eight months?

By successfully I don't mean economically; we have not come to that yet. The question of cost is in this case only of secondary importance, and I am first desirous of locating any instances of primary batteries giving a steady constant current nightly for any period over six months.

I do not wish to exclude "damaging" information as this is also of importance; and although I fear voluminous accounts could be written on this head, I should be glad to hear of any personal experiences of your readers.

It is only by enquiries such as the above that really reliable facts can be tabulated, and therefore such information will be of value and highly esteemed by

Jno. B. Verity.

Moorcroft, Weybridge,
April 10*th*, 1886.

[The information obtainable by the means suggested would, we believe, be of the slightest, and, we much fear, for the most part unreliable.—EDS. ELEC. REV.]

Charging Secondary Batteries.

Referring to your note on page 334, I fear that my letter was, in this respect, somewhat inaccurately worded. But if your friend will kindly refer to the tabulated statement which accompanied it, he will observe that a diminution of current *is* recorded towards the end of the afternoon's charging. And any other result would, as it seems to me, be inconsistent with the fundamental equation which controls the mutual relationship of E C and R.

Thomas S. Bazley.

Athenæum Club, Pall Mall,
April 12*th*, 1886.

"Compound Wound Dynamos in Parallel."

Twelve Crompton-Bürgin compound wound dynamos were connected and working in parallel circuit at the Law Courts in 1883. A plan of the switch board was illustrated in the ELECTRICAL REVIEW, I believe, in December, 1882.

A. Grundy.

April 13*th*, 1886.

With reference to Mr. E. W. Rice, jun.'s, letter in your last issue, the method of connecting dynamos in parallel, by joining together both similar terminals and similar brushes, is not new, as it was used several years ago with Gramme machines.

Messrs. Sautter, Lemonnier & Co.'s representative thus connected two A Grammes for our trials in 1879, and stated that it was the method they usually adopted. Of course these were series machines, but the difficulty lies in the series winding.

P. Cardew.

Chatham, *April* 12*th*, 1886.